NPS-GSBPP-19-001

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

INTANGIBLE BENEFITS IN THE COMPOSITION OF THE MARINE CORPS: AN OCCUPATION-BASED FRAMEWORK

by

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January 2019

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Prepared for: HQMC M&RA

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE ***(DD-MM-YYYY)***
30-01-2019

2. REPORT TYPE
Final Technical Report

3. DATES COVERED ***(From-To)***
10/01/2017 – 09/30/2018

4. TITLE AND SUBTITLE
Intangible Benefits in the Composition of the Marine Corps: An Occupation-Based Framework

5a. CONTRACT NUMBER

5b. GRANT NUMBER
Naval Research Program

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER
NPS-18-M222-A

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)
Naval Postgraduate School
School: Graduate School of Business and Public Policy/ Dept: Manpower & Economics
1 University Circle, Monterey CA 93943

8. PERFORMING ORGANIZATION REPORT NUMBER
NPS-GSBPP-19-001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES
The views expressed in this technical report are those of the authors and do not reflect the official policy or position of the Department of Navy, Department of Defense, or the U.S. Government.

14. ABSTRACT
Women comprise approximately 8% of the active component in the Marine Corps, a number less than half of female representation in other military services. While the DoD's recent mandate to fully integrate women is not the focus of this project, the policy dramatically increases the set of opportunities the Marine Corps can offer to women. This project seeks to provide a foundation to ultimately help determine the "optimal" number of women in the Marine Corps.

In particular, we determine what a feasible level of gender integration could look like by creating an empirically justified upper bound of female representation across Marine Corps occupations. To establish this, we develop a mapping of Marine military occupational specialties (MOS) to its civilian equivalents using detailed job descriptors. We find previously male-only Marine MOS are equivalent to primarily male-dominated civilian jobs, where the proportions of women still sit at or below 5 percent. There is substantial variation in female representation across Marine jobs, however; for example, women comprise more than 25 percent in the Manpower/Admin Occupational Field (OCCFLD). The analysis reveals the occupational segregation in the Marine Corps closely mirrors that of the civilian labor market.

Because some Marine jobs do not map well to civilian equivalents, we also examine determinants of success at infantry training. Finding that physical ability is the dominant predictor of success, we use physical fitness data of male and female civilian youth to further estimate the proportions of women we may expect in the infantry OCCFLD. Finally, we develop an analytical framework that can address the costs and benefits of increasing the proportion of women in the Marine Corps.

15. SUBJECT TERMS
Gender, Integration, Recruitment, Female Marines, Occupational Specialties

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Dr. Marigee Bacolod
Unclassified	Unclassified	Unclassified	UU	82	**19b. TELEPHONE NUMBER *(include area code)*** 831-656-3302

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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The report entitled "Intangible Benefits in the Composition of the Marine Corps: An Occupation-Based Framework" was prepared for "Headquarters Marine Corps Manpower and Reserve Affairs (HQMC M&RA)" and funded by "Naval Research Program."

Further distribution of all or part of this report is authorized.

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NRP FY18 TECHNICAL REPORT

Intangible Benefits in the Composition of the Marine Corps: An Occupation-Based Framework

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ABSTRACT

Women comprise approximately 8% of the active component in the Marine Corps, a number less than half of the female representation in other military services. While the DoD's recent mandate to fully integrate women is not the focus of this project, the policy dramatically increases the set of opportunities the Marine Corps can offer to women. This project seeks to provide a foundation to ultimately help determine the "optimal" number of women in the Marine Corps.

In particular, we determine what a feasible level of gender integration could look like by creating an empirically justified upper bound of female representation across Marine Corps occupations. To establish this, we develop a mapping of Marine military occupational specialties (MOSs) to its civilian equivalents using detailed job descriptors. We find that previously male-only Marine MOSs are equivalent to primarily male-dominated civilian jobs, where the proportions of women still sit at or below 5%. There is substantial variation in female representation across Marine jobs, however; for example, women comprise more than 25% in the Manpower/Admin Occupational Field (OCCFLD). The analysis reveals the occupational segregation in the Marine Corps closely mirrors that of the civilian labor market.

Because some Marine jobs do not map well to civilian equivalents, we also examine determinants of success at infantry training. Finding that physical ability is the dominant predictor of success, we use physical fitness data of male and female civilian youth to further estimate the proportions of women we may expect in the infantry OCCFLD. Finally, we develop an analytical framework that can address the costs and benefits of increasing the proportion of women in the Marine Corps.

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I. EXECUTIVE SUMMARY

Introduction

When the combat exclusion for women in the military was lifted in 2016, the new policy made 54,000 billets—approximately 1/3 of the entire Marine Corps Table of Organization—available to qualified women. In addition, 32 previously closed primary military occupational specialties and 16 additional military occupational specialties were opened to women. While the change in the combat exclusion policy is not the focus of this project, the policy change has dramatically altered the nature and quantity of the opportunities the Marine Corps can offer to women. In light of these changes, it is necessary for the Marine Corps to assess the current status of women in the corps, anticipate how the roles female Marines fill may evolve over time, and determine the extent to which resources should be used to shape that evolution.

Women make up approximately 8% of the active component of the Marine Corps, a number well less than half of the proportion of women in the other military services. Currently, the Deputy Commandant for Manpower and Reserve Affairs has no tools at his disposal to assess whether 8% is too many or too few. One can imagine a wide array of benefits that additional women would bring to the Marine Corps. However, given the unique challenges that life as a Marine offers, it is also the case that the Marine Corps tends to draw recruits from a vanishingly small pool of qualified and interested candidates.

Our research goals are three-fold:

1. Using the hedonic approach, determine feasible upper bounds of proportion of women in Marine occupational fields by matching it to its civilian equivalents.
2. Because some Marine combat occupations do not map well to civilian jobs, determine the factors that predict success at schools that comprise Infantry Training Battalions and use this to predict proportions of women in these occupational fields.
3. Develop a cost-benefit analytical framework for thinking about an “optimal” number of female Marines.

As such, we intend for our research to provide a point of departure from which the Marine Corps may ultimately determine the “right” number of women in the Marine Corps.

Research Methods and Findings

To address our first research goal, we relate each job specialty in the Marine Corps to its civilian equivalent. We turn to two data sources: a website called My Next Move for Veterans (MNMV) developed by the U.S. Department of Labor to aid military service members transitioning into the civilian labor market, and the Occupational Information Network (O*NET). Occupational data in the O*NET are the result of comprehensive studies of how jobs throughout the U.S. economy are performed, including the required knowledge, skills, and abilities required for job performance. Data from 2000 to 2017 on gender concentration for each civilian Standard Occupational Classification (SOC) code come from the U.S. Census Bureau, while the equivalent data on Marines come from the Total Force Data Warehouse (TFDW). For consistency in analyses over time, we also reference the U.S. Marine Corps MOS Manual, as some Marine job titles were reclassified, merged, or deleted. Using data of detailed job descriptors from MNMV, O*NET, the MOS Manual, and prior literature, we develop a crosswalk of Marine occupational fields (PMOSs) to their civilian equivalents (SOC). Major Angela Zunic's master's thesis supports these efforts.

Mapping Marine MOSs to their equivalent SOC, Zunic (2018) finds a very heavily male-dominated civilian sector for equivalent Marine occupations. Specifically, the previously male-only Marine occupations in combat arms are largely equivalent to civilian occupations such as firefighting, where female representation currently still sits at or below 5%. This highlights the occupational segregation across civilian labor markets, indicating a low supply of female workers choosing to be in or being hired for such jobs. Meanwhile, there is substantial variation in these occupational comparisons. For example, the 31xx Distribution Management Marine OCCFLD has similar gender representation (26%) with its civilian equivalent of logisticians. In contrast, the 01 Manpower and Administration OCCFLD has 25% female while its civilian equivalent, human resources, is 80% female.

Suppose we assume that the civilian labor market is sufficiently close to an equilibrium, where men and women have sorted into occupations that best utilize their skills and abilities for which they get the best possible reward. Under this hedonic assumption and using the occupational crosswalk, we can then develop an econometric model where we regress representation on multiple job characteristics such as skills, abilities, and knowledge required for job performance using data from the O*NET. The coefficients on these regressors have the interpretation as the marginal proportion of women for a one-unit change in that job characteristic. Knowing what the detailed job descriptors of Marine OCCFLDS are, we can then predict the proportion of women for each OCCFLD.

Next, we recognize that the O*NET database may not map well to some Marine occupational fields, particularly occupations in the combat arms. Of course, the combat arms comprise the very occupations that have just opened to women, so there is also a lack of institutional experience with respect to the performance and retention of women in those fields. To mitigate this gap, we examine the determinants of success at the schools that comprise the Infantry Training Battalions (ITB). The thesis by Major John “Jake” Dove and Captain Brian Richmond supports these efforts.

Dove and Richmond (2017) find that physical health and performance account for almost 80% of failures at the Marine Corps’ ITB. Using data from several cohorts of enlisted Marines that attended ITB-West and ITB-East, logistic and multinomial logistic regression model estimates show that by and large physical abilities—as measured by performance on constituent events in the PFT, CFT, and rifle scores—are the largest predictors of success. Some dimensions of cognitive ability also matters, while characteristics such as height and weight have nonlinear predictive effects.

Our project’s final effort is to devise a way to think about the benefits and costs the Marine Corps may experience as they attempt to increase the number of females on active duty. Captain Viviana Lee’s thesis attempts this by examining the implications of integration on recruiting and readiness.

In particular, Lee (2018) examines aspects of recruiting females into the infantry MOS, extending the findings by Dove and Richmond (2017). She turns to data from the California Department of Education (CDOE) of California high school students’ measures of physical fitness equivalent to the constituent events in the Marines’ PFT (i.e., pull-ups, crunches, mile run). These physical fitness outcomes are for the population of ninth graders in the state of California during the 2016–2017 school year. One limitation of this data is that ninth graders are typically 14–15 years old, when we would ideally like to observe performance of 17-year olds. Using the CDOE dataset and estimates from the predictive model using the ITB data that Dove and Richmond (2017) developed, Lee (2018) finds that the expected probability that the average ninth grade male graduates from ITB is 0.89, while only 0.17 for the average female in the CDOE data. On the other hand, analysis of CDOE data shows some evidence in favor of the idea that young females capable of becoming Marines and attaining Marine physical standards are higher in the quality distribution of their gender relative to young males.

Imagine the pool of male civilians from age 18 to 26. Suppose we were to rank those individuals with respect to their quality or their ability to not only earn the title "Marine" but succeed in their first term of enlistment. We are likely to find that the marginal Marine, that is, the Marine who barely succeeds at basic training and/or their MOS school, but then goes on to perform adequately in their first term, is found at or about the 30th percentile of this distribution. It is important to ponder this recruit's alternatives to joining the Marine Corps. Given his position on this distribution of quality, it is unlikely he is heading to a four-year college. Anecdotally, and given his comparative advantage, we might imagine him as working construction over the summer and planning to start community college in the fall.

Now instead consider the same quality distribution for female civilians age 18–26. Given the physical rigors of Marine Corps entry and training, the marginal female that signs up for a traditionally open MOS (i.e., administrative clerk, logistics, etc.) is likely to be in the 50th or 60th percentile of the quality distribution. And since entry into combat arms MOSs is even more physically demanding than non-combat arms MOS, the marginal female capable of succeeding at ITB is likely to be substantially higher on the quality distribution than her non-combat counterpart. It is reasonable to suppose that the marginal female combat arms recruit is a very good athlete relative to her female peers and perhaps has opportunities to play sports in college. She may even have an athletic scholarship.

Such a scenario is in theory, of course, the conditions for which we discuss in more detail in this paper. Findings by Lee (2018) using CDOE data provide suggestive evidence consistent with the scenario. Thus, in order for the Marine Corps to think about costs and benefits of accessing additional females, it must compare the intensity of effort and resources to expend to recruit females in comparison to males, while balancing against relative benefits. A full treatment of benefits would likely require a rigorous structural analysis to appropriately estimate the value of the work the additional women would provide the Marine Corps. For example, one possible method would be to use the value of the candidate's next best civilian alternative as a measure of the value of their work. Such an analysis is beyond the scope of this current effort, however.

We examine data collected as part of the Joint Advertising Market Research & Studies (JAMRS) program. We use data from the Fall 2017 DoD Youth Poll to address our hypothesis regarding the relative qualities of the marginal male and female recruits. Ultimately, we find evidence broadly consistent with the notion that conditional on quality level, females tend to have lower propensity to join the Marine Corps. However, the data only contains information on academic quality, whereas athletic ability is a central part of our hypothesis.

What we instead examine on the benefits side are the likely implications of integration on force readiness. Lee (2018) uses TFDW data from 2009 to 2017 to examine the extent to which males and females differ in maintaining a deployable status and how deployability by gender varies across MOS. The purpose is to get a sense of the manner in which Marines of different genders and occupational specialties contribute to the production of combat effectiveness. While the status "deployable" is an imperfect metric for a Marine's productivity, one could argue that Marines who are *deployable* are able to contribute more directly to the organization's ability to produce combat effectiveness; they are ready to be called to perform relevant operational duties. Lee (2018) finds that on average females are less deployable than males during the first four years of service, with the differences peaking during months 25–36, with the major cause of a female's unavailability being pregnancy.

Recommendations

We recommend further research on constructing an MOS to SOC crosswalk. This can be done using survey instruments administered to Marines in those particular jobs, inquiring on the particular skills, abilities, work styles, work content, and others, for job performance. Such an enhanced crosswalk would be valuable for determining the next best opportunities for Marines in the civilian labor market, which in turn can answer multiple manpower planning policy questions.

We also recommend further research into ways to more clearly identify gender differences in recruiting effort intensity. Finally, since our analysis reveals injuries were a substantial reason for failure from ITB, we also recommend a more focused study on the determinants of injuries at ITB.

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II. BACKGROUND

Women in Military Service in the United States

Military service by women in the United States is not a new phenomenon. As Major General Jeanne Holm (1982) states,

> Women's participation in the military is not, as many believe, of recent origin—it goes back to our nation's beginnings. The extent of their involvement and the degree to which they have been "militarized" and integrated into the services are, however, significant departures from the past and have become major subjects of controversy in recent years. (p. xv)

Throughout the years, numerous policy changes and studies relating to female service in the U.S. military have been undertaken. Table 1 shows a comprehensive timeline from World War II to 1994's Direct Ground Combat Definition and Assignment Rule (DGCDAR). Table 1 and the following discussion on the background of women in combat are drawn from the thesis work by Dove and Richmond (2017).

Table 1. Timeline of Women in Service. Source: Dove & Richmond (2017).

1942	Public Law 689 authorized the establishment of the Navy Women's Reserve and the Marine Corps Women's Reserve. "In November 1942 General Holcomb recommended to the Secretary of the Navy that as many women as possible should be used in non-combat billets thus releasing a greater number of the limited manpower available for essential combat duty" (Stookbury, 1997, p. 14).
1948	"The Women's Armed Services Integration Act was passed by Congress to establish a separate women's corps. It limited enlisted women to 2 percent of enlisted strength, and women officers to 10 percent of officer strength, and the paygrade of female officers to O-5" (Adside & Porter, 2011).
1951	"The Defense Advisory Committee on Women in the Services (DACOWITS) was established by Congress to advise the Secretary of Defense on matters pertaining to women's recruiting, retention, and skill integration in the armed services" (Adside & Porter, 2011).

1956	Part of the Armed Forces Integration Act of 1948, the combat exclusion laws became part of Title 10, U.S. Code (Adside & Porter, 2011).
1964	Employer anti-discrimination laws were created by Title VII of the Civil Rights Act. The applicability of Title VII to the military remained ambiguous (Adside & Porter, 2011).
1967	Public Law 19-130 repealed the 2% total force and O-5 rank limitations of women in the military (Adside & Porter, 2011).
1969	Women were first admitted to Air Force Reserve Officer Training Corps (ROTC; Adside & Porter, 2011).
1972	Women were first admitted to Army and Navy ROTCs. The Navy also allowed women to command shore units while also expanding restrictions on various enlisted ratings (Adside & Porter, 2011).
1973	The draft ended at the closing years of the Vietnam War and the military transitioned to an all-volunteer force. At this time, the Army and Navy opened flight training to women and the Supreme Court ruled, in *Frontiero v. Richardson*, that dependents of female service members are equally eligible for military benefits as male service member dependents (Adside & Porter, 2011).
1974	The DoD rescinded the policy of involuntary separation for women who become pregnant. Additionally, the enlisted age requirement for females without parental consent was decreased from 21 to 18 (Adside & Porter, 2011).
1975	Women are authorized to apply to service academies through the Stratton Amendment to the Defense Authorization Bill (Adside & Porter, 2011).
1976	Women were accepted in service academies and the Air Force opened flight training to women (Adside & Porter, 2011).

1977	"The Secretary of the Army issued a combat exclusion policy prohibiting women from being assigned to combat arms units, since the Armed Forces Integration Act of 1948 did not contain statutes restricting Army women" (Adside & Porter, 2011).
1978	Through Public Law 95-485, Congress fully integrated females from the Women's Army Corps into the regular Army (Porter & Adside, 2011). Additionally, the military implemented the Military Entrance Physical Strength Capacity Test (MEPSCAT) that screened service members for physically demanding jobs without being racially or sexually biased (Stooksbury, 1977).
1981	In *Rostker v. Goldberg*, the Supreme Court upheld male-only registration for the draft (Adside & Porter, 2011).
1984	"The Commandant approved the results of the Women Review Board which focused on classification, assignment, and deployability of women Marines. Those results included the establishment of the ideal enlisted women Marine strength at about 10,500 and that women would continue to serve in all major commands, both Fleet Marine Force and supporting establishments" (Stooksbury, 1977).
1985	The Air Force assigns the first women to the Minutemen and Peacekeeper ballistic missile silos (Adside & Porter, 2011).
1988	The DoD implements the "Risk Rule" which highlights that "non-combat units should be open to women unless the risk of exposure to direct combat, hostile fire, or capture is equal to or greater than that experienced by associated combat units in the same theater of operations" (Adside & Porter, 2011, p. 50).
1990	The previously implemented physical screening tool, MEPSCAT, was eliminated at all Military Enlistment Processing Stations because of the unpopular enlistment barriers it imposed on recruiters (Stooksbury, 1977).

1991	“Senators William Roth, Jr. (R-DE) and Edward Kennedy (D-MA) introduced Amendment No. 948 to Congress to repeal laws excluding women from combat” (Adside & Porter, 2011). “Senators John Glenn (D-OH), John McCain (R-AZ), Sam Nunn (D-GA), and John Warner (R-VA) introduced Amendment No. 949 to Congress to repeal aviation combat exclusion laws temporarily to study the issues regarding women in combat” (Adside & Porter, 2011). “The Defense Authorization Act (Public Law 102-190) was passed by Congress to repeal the laws that excluded women from combat aviation” (Adside & Porter, 2011). “The Presidential Commission on the Assignment of Women was created by Armed Forces Public Law 102-190 to study the issue of integrating women into combat units” (Adside & Porter, 2011). “The Commission conducted a comprehensive review of service policies and analyzed the physiological rigors of the direct ground combat arms service members through testimony, comprehensive research, and public surveys” (Mull, 2016, p. 8).

1992	“The Presidential Commission on the Assignment of Women in the Armed Forces recommended that aviation and ground combat jobs remain closed to women” (Adside & Porter, 2011). “The Commission found that despite technological advances, the characteristics of direct ground combat remained just as hazardous and physically demanding as in previous generations. Additionally, the Commission cited evidence of the distinct physiological differences between genders; specifically, women are shorter in stature, have less muscle, and weigh less than men. Inferior muscular strength and aerobic capacity place women at a distinct disadvantage when performing tasks required for direct ground combat specialties, which include marching under load for prolonged periods, lugging weapons and ammunition, navigating obstacles, and carrying the wounded or dead. The Commission also determined that while some women would meet the physical standards for direct ground combat arms specialties, the evidence showed most women are physically incapable of meeting the standards” (Mull, 2016, p. 8).
1993	Public Law 103–160 permitted women to serve on combat vessels and combat aircraft (Mull, 2016).

1994	The DGCDAR replaced the Risk Rule. “While the DGCDAR substantially expanded the roles of women in the military, women were still restricted from serving in units whose primary mission below the brigade level is direct ground combat” (Mull, 2016). “The Secretary of Defense defined direct ground combat as: Engaging an enemy on the ground with individual or crew served weapons, while being exposed to hostile fire and to a high probability of direct physical contact with the hostile force’s personnel. Direct ground combat takes place well forward on the battlefield while locating and closing with the enemy to defeat them by fire, maneuver, or shock effect” (Adside & Porter, 2011, p. 23). Other specifications of exclusion included: “Berthing and Privacy: Military Departments could restrict positions where the costs of appropriate berthing and privacy agreements were prohibitive” (Department of Defense [DoD], 2015c). “Co-Location: Military Departments could restrict units and positions that were doctrinally required to physically co-locate and remain with direct ground combat units that were otherwise closed to women” (DoD, 2015c). “Long Range Reconnaissance and Special Operations Forces: Military Departments could restrict certain positions involving long range reconnaissance operations and Special Operations Forces missions” (DoD, 2015c). ”Physically Demanding Task: Military Departments could restrict positions, which included physically demanding tasks that would exclude the vast majority of women” (DoD, 2015c).

Recent Policies on Women in Combat: DGCDAR from 1994 to present

The DGCDAR remained the standard for DoD policies regarding female service in combat units over the following two decades. From about 2011 to 2012, the DoD reviewed the DGCDAR and subsequently rescinded the Co-Location Rule while also opening 14,325 positions to females throughout each of the services. Secretary of Defense Leon Panetta followed with the directive that each service would conduct an in-depth review of the remaining closed jobs (DoD, 2015c).

That same year, in 2012, four servicewomen and the American Civil Liberties Union sued the DoD for the implementation of the DGCDAR, claiming that the current policy prevented women from ascending through the ranks. Other interest groups like the Military Leadership Diversity Commission also protested that too many women were absent from senior enlisted and officer ranks (Mull, 2016).

By January 24, 2013, after continuous integration study, Secretary Panetta and General Martin Dempsey officially declared the full repeal of DGCDAR and tasked each service chief to conduct a comprehensive internal study on how they would implement integration in their service (DoD, 2015c). They also had until January 1, 2016, to fully integrate or present any requests for exemptions to policy to the Secretary of Defense (DoD, 2015c).

Marine Corps Women in Service Restriction Review (WISRR)

In response to the secretary and defense's and chairman's directive, the military services conducted more than 30 primary studies and reviews regarding the policy change (DoD, 2015c). Specifically, the Marine Corps studied a variety of physically demanding and dangerous jobs outside of the military such as firefighters, smokejumpers, and Special Weapons and Tactics (SWAT) teams. They found that, although open to females for decades, those jobs have very few females: 4% firefighters, 7% smokejumpers, and virtually none in SWAT teams (Amos, 2014). The Marine Corps also studied allied militaries that integrated females into their ground combat units. They found that in Australia and Britain, females were successful in meeting entry-level physical standards but were not successful in meeting critical combat related tasks. Such tasks, according to General Amos' directed study, include movement under load, maneuvering through obstacle courses, digging under fire, rapidly moving with heavy weights, and conducting timed fire and movement drills. It was also found that, in both countries, females in ground units suffered very high injury rates. While studying the Canadians, it was found that, although they had been allowed to serve in ground combat arms since the 1980s, only 2% of females met the physical standards to serve (Amos, 2014).

The largest study conducted by the Marine Corps concerning the integration of females into ground combat units was the WISRR, later changed to the MCFIP. This study had four LOEs that formed, as described by former Commandant of the Marine Corps, General James Amos, a "deliberate, measured, and responsible approach to validating standards, providing equitable opportunities, ensuring the availability of viable career paths, and, most critically, maintaining and increasing combat readiness.…end state: analysis complete, standards validated, occ fields integrated, unnecessary gender barriers eliminated, policies and directives in place" (Amos, 2014, para. 15 and Figure 1).

a. LOE 1: Expand Unit Assignment

This first line of effort focused on expanding female integration into previously closed ground combat MOSs. This included the assignment of "female officers and SNCOs (Staff Non-Commissioned Officers) to these selected 21 Active Component and 9 Reserve Component units (to include artillery, tank, assault amphibious vehicles [AAV], combat engineers, low altitude air defense, and air naval gunfire liaison companies" (Amos, 2014). It also involved the expansion of job assignments from only higher headquarters down to the company and battery level while giving authority to commanders to deploy any assigned females (Amos, 2014).

b. LOE 2: Expand Entry-Level Training

The purpose of this line of effort's study was to determine the success rates, assess propensity, and analyze injury rates at entry-level training (Amos, 2014). From September 2012 to June 2015, research was executed at multiple training locations that included IOC in Quantico, Virginia; ITB-E at Camp Geiger, NC; Marine Detachment at Fort Benning, GA; Marine Detachment at Fort Sill, OK; and AAV School Camp at Pendleton, CA. The study focused on integration at infantry officer entry-level training, enlisted infantry entry-level training, and officer and enlisted non-infantry ground combat arms entry-level training. The studies find that at IOC, only 24 out of the 454 (5%) of eligible female lieutenants volunteered to participate. Out of those 24 females, none passed the course. However, 23 were physical performance failures while one dropped from a stress fracture that resulted from multiple load-bearing hikes. At ITB-East, only 1,504 out of the 3,614 (42%) eligible enlisted females met the physical prerequisites to even volunteer. Out of those 1,504 eligible enlisted females, only 516 (34%) volunteered to attempt the ITB Program of Instruction (POI). With 115 dropping on request at checkin, 401 actually began the POI. Only 144 females (35.9%) graduated while 257 (64%) dropped out. Out of those 257 females who dropped, 124 (48%) were for physical performance failures, 89 (35%) dropped on request, 23 (9%) were for injuries, 15 (6%) were weapons failures, and six (2%) were academic failures. At non-infantry combat arms formal learning centers (FLC), there were 61 females eligible to volunteer out of the solicited population. Additionally, 28 out of the 61 (46%) started training at the various FLCs. Out of those 28 who started, seven attended Tank Crewman Course at Fort Benning, GA, 14 started Cannon Crewman Course at Fort Sill, OK, and seven started AAV Crewman Course at Camp Pendleton, CA. Also, four out of seven females (57%) graduated Tank Crewman Course. The three failures were attributed to the Handling/Loading of Tank Ordnance task. Twelve out of 14 females (86%) graduated from Cannon Crewman Course. The two failures were attributed to the Handling/Loading of Artillery Ordnance task. Five out of seven females (71%) graduated from AAV Crewman Course. The two failures were attributed to academic performance (DoD, 2015b).

c. LOE 3: Ground Combat Element Integrated Task Force (GCE-ITF)

Although certain females may be able to pass the minimum standards at entry-level training, they only provide a minimum baseline for success in the Operating Forces. Combat-related jobs within ground combat units, specifically infantry units, require a more advanced degree of individual and collective physical requirements than what is expected at entry-level training (Amos, 2014). The GCE-ITF study, conducted from 2014 to 2015 at Camp Lejeune, NC, and Marine Corps Air Ground Combat Center, Twentynine Palms, CA, compared performance of gender-integrated units and all-male units in a variety of missions associated with ground combat. The goal of the study was to determine what impacts gender integration may have on small units, specifically mission effects, cohesion, readiness, workload, and fatigue (DoD, 2015c). General James Amos, commandant of the Marine Corps, had a null hypothesis that "an integrated ground combat arms unit under gender neutral standards will perform just as well as a similar all male unit" (Amos, 2014, para. 18). The GCE-ITF concluded that "the all-male units outperformed gender-integrated units on 69% of the 134 tasks that were evaluated, according to the summary. The integrated teams performed better in two machine-gun related tasks than the all-male teams. There was no difference on the remaining tasks" (Michaels, 2015). Overall, according to the study, the all-male units moved faster (particularly under heavy load), were better marksmen, were better at negotiating obstacles, and had a much lower injury rate than the integrated units (Michaels, 2015). However, there were also critics of the study's findings who claimed that the Marine Corps intentionally misused data to achieve a desired conclusion. Ellen Haring of the interest group Women in International Security claimed that "the Marine Corps has always been looking for data that would justify continued exclusion of women from the infantry" (Walters, 2015, para. 10). Then Secretary of the Navy Ray Mabus also criticized the study, calling it flawed for measuring average performance rather than individual capabilities. He even went as far as accusing male Marines of not wanting to see females succeed (Harkins, 2015).

d. LOE 4: Early MOS Opening

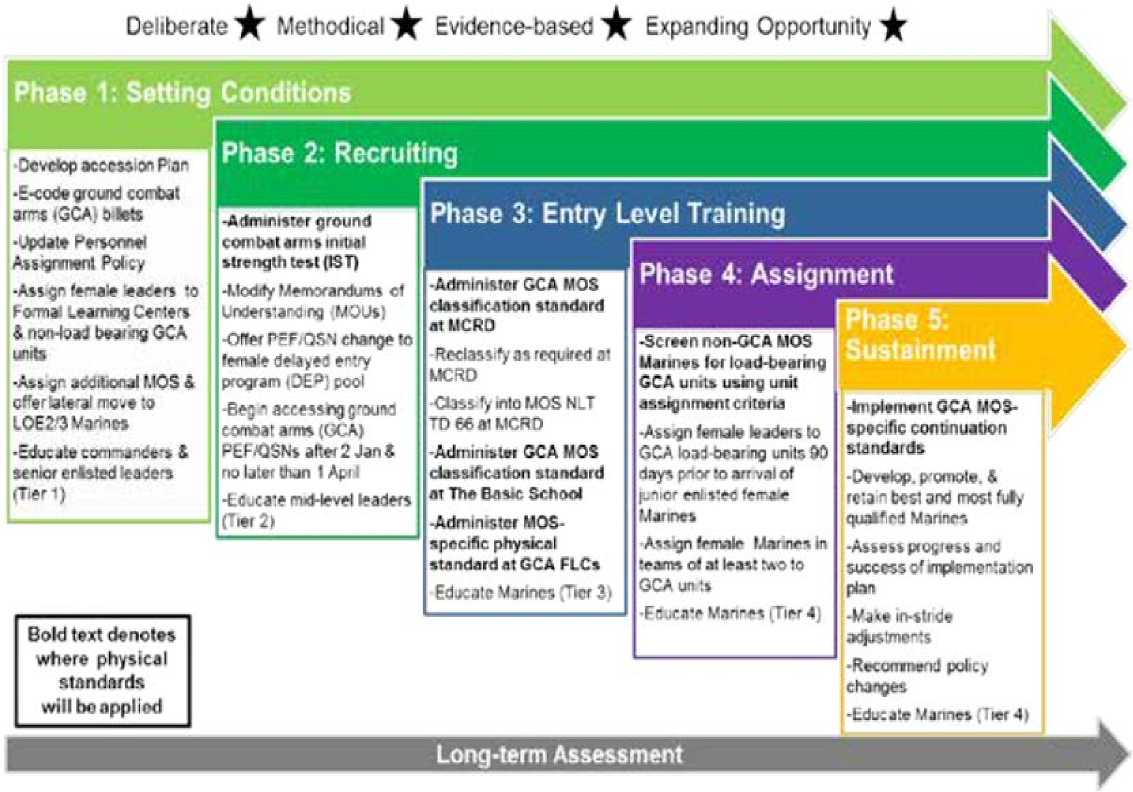
This line of effort focused on the opening of many previously closed MOSs that the Marine Corps determined, based on previous studies, were fully capable of handling gender integration. These MOSs included "0803 (Target Acquisition Officer), 0842 (Field Artillery Radar Operator), 0847 (Field Artillery Meteorologist), 2110 (Ordnance Vehicle Maintenance Officer), 2131 (Towed Artillery Repairer/Technician), 2141 (Assault Amphibious Vehicle Repairer/Technician), 2146 (Main Battle Tank Repairer/Technician), 2147 (Light Armored Vehicle Repairer/Technician), 2149 (Ordnance Vehicle Maintenance Chief), 7204 (Low Altitude Air Defense Officer), 7212 (Low Altitude Air Defense Gunner)" (Amos, 2014). Each of these occupational field sponsors gave their recommendations for integration to the commandant, who forwarded the request to the secretary of the Navy (Amos, 2014).

As integration studies continued, the new secretary of defense, Ashton Carter, reiterated, "The department's [DoD] policy is that all ground combat positions will be open to women, unless rigorous analysis of factual data shows that the positions must remain closed" (Michaels, 2015, para. 7). It was on September 30, 2015, that the service chiefs submitted their final recommendations. Based on the MCFIP studies, the

Commandant of the Marine Corps requested two exemptions to policy that included 48,779 Active and Reserve Component jobs. The first exemption request was focused on specific MOSs. These included “Infantry Officer, Infantry Weapons Officer, Rifleman, Light Armored Vehicle Crewman, Reconnaissance Man, Machine Gunner, Mortarman, Infantry Assaultman, Antitank Missileman, Infantry Squad Leader, Infantry Unit Leader, Special Operations Officer, Critical Skills Operator, and Fire Support Man” (DoD, 2015c). The second exemption request was focused on specific units. These included “Infantry Regiments and below, Reconnaissance Battalions, Light Armored Reconnaissance Battalions, Force Reconnaissance Battalions, Marine Raider Companies, and Combat Engineer/Assault Companies” (DoD, 2015c). Navy Secretary Ray Mabus forwarded the request without approval to Secretary of Defense Ash Carter. After review, Secretary Carter denied all exemptions to policy and officially opened all MOSs to females (DoD, 2015c). He publicly announced, “While the Marine Corps asked for a partial exception in some areas such as infantry, machine gunner, fire support, reconnaissance, and others. We are a joint force and I have decided to make a decision which applies to the entire force” (Associated Press, 2015, 0:52–1:08). On December 3, 2015, Secretary Carter directed that all service chiefs provide their detailed plans for female integration no later than January 1, 2016. From there, each service was directed to implement their integration plan as soon as January 2, 2016, but no later than April 1, 2016 (DoD, 2015c).

In response to Secretary Carter’s final directives, the commandant of the Marine Corps released Fragmentary Order 4, the implementation of the MCFIP, on December 16, 2015. This implementation was composed of five phases that are outlined in Figure 1: Phase 1—Setting Conditions, Phase 2—Recruiting, Phase 3—Entry Level Training, Phase 4—Assignment, and Phase 5—Sustainment (DoD, 2015a). A more thorough discussion of these phases and how they relate to Infantry Training Battalions (ITB) in our study can be found in Dove and Richmond (2017).

Figure 1. MCFIP Concept of Operation by Phase. Source: DoD (2015a).



Related Literature: Impacts of Gender Diversity in the Civilian Sector

The literature in labor economics on gender diversity and differences in labor market outcomes for males versus females is extensive and very well developed. Studies have also systematically documented that women are far more likely than men to leave the Navy and the Marine Corps before completing their minimum service obligation (e.g., Bacolod & Chaudhary, 2016; Chaudhary 2017) and are less likely to re-enlist (Ceralde & Czepiel, 2014). Bacolod and Chaudhary (2016) in particular find that gender gaps in attrition in the first six months of service have significantly increased in the U.S. Navy as the proportion of women enlisting has increased from 2000 to 2011. This research study is focused on the benefits of gender diversity in the Marine Corps, however. To that end, this review of relevant academic literature summarizes studies related to the impacts of gender diversity in the civilian sector.

For instance, a large body of work investigates how gender composition in corporate boards affects board policies and firm productivity. Findings vary from a large positive effect of gender diversity on corporate boards to others documenting little to no significant effects on outcomes such as stock prices, firm innovation, and gender wage gaps (see Carter et al., 2010; Torchia et al., 2011; Francoeur et al., 2012; Jhunjhunwala & Mishra, 2012; O'Reilly & Main, 2010; and Alvarado et al., 2011, among many others).

Identifying the causal effect of gender composition on various outcomes is complicated by the empirical problem of endogeneity, however. Firms with a larger representation of female board members are also simultaneously more likely to be more productive, inducing reverse causation and limiting inference of the causal effect of gender composition on firm productivity. The main problem is that companies do not randomly assign women to their boards. Firms that have a larger representation of female board members are just fundamentally different than firms with a smaller proportion of female board members. While some studies get around this issue by exploiting within-firm variation and control for firm fixed effects, the results generally lack statistical power to detect the effects of female representation on outcomes.

A compelling study that gets around the problem of endogeneity exploits a law change in Norway to estimate the causal effect of gender diversity. Bertrand, Black, Jensen, and Lleras-Muney (2014) find that a 2003 Norwegian law mandating all publicly traded companies had to have at least 40% female representation effectively increased the number and proportion of women on corporate boards without any loss in firm quality or productivity. However, the authors find no significant effects of the mandate on gender gaps in wages at these companies, nor do they find any significant effects on male-female enrollment in business programs, nor any other significant impact.

Meanwhile, in the political economy sphere, another set of studies estimate the effect of female political representation, particularly in developing countries. For example, Duflo and Chattopadhyay (2004) find that a higher mandatory representation of women on Indian village councils leads to higher public spending on goods that improve the relative welfare of women than men. The findings in this area generally show that higher female representation leads to significant changes in public spending outcomes; however, it is difficult to extrapolate these findings to more developed countries such as the United States.

Related Literature: Gender Integration in the Military

Several foreign militaries have undergone gender integration, and some were relatively more successful than others. A 2015 RAND study finds that foreign militaries that have strong leadership commitment to integration, recruitment and retention policies that target women, and continual revision of gender-neutral physical standards were more likely to be successful in their efforts towards gender integration (Schaefer et al., 2015). Table 2 summarizes these findings by country.

Table 2. Assessment of Integration Success in Foreign Militaries. Source: Schaefer et al. (2015).

Assessment of Integration Success and Institutional Commitment in Foreign Militaries

	Institutional Commitment		
Integration Success	**High**	**Moderate**	**Low**
High	Australia Canada Denmark Norway Sweden Israel		
Moderate	Germany Netherlands New Zealand South Africa	Albania Belgium Finland Hungary Italy Romania Slovenia Spain	France
Low		Croatia Greece Latvia Lithuania Mexico Russia	Poland Portugal Slovakia Ukraine

While the academic literature on the impacts of gender diversity in the civilian labor market is fairly robust, compelling empirical evidence in the military context is relatively thin. Studies such as those displayed in Table 2 are more correlational and descriptive rather than causal. A notable exception is the recent paper by Dahl et al. (2018) that implements a randomized assignment of Norwegian female recruits to mixed gender teams at boot camp, in order to examine whether the integration of men and women during basic military training changed attitudes about mixed-gender productivity, gender roles, and gender identity. Dahl et al, (2018) find a 14-percentage point improvement in the fraction of men who think mixed-gender teams perform as well or better than same-gender teams. They also do not find any evidence that female integration hurt male recruits' satisfaction with boot camp or their plans to continue in the military. While this study does not provide evidence of the productivity effects of gender integration, the study does establish that gender attitudes are highly malleable by exposure of traditionally male teams to women.

Meanwhile, new research finds mixed evidence for the effect of a critical mass of women in retention of U.S. Navy sailors at the military occupation (MOS) level. Hartmann (2017) uses logistic regressions to find that in the U.S. Navy, both male and female enlistees have higher odds of attriting in the first six months of service from MOSs with more than 25% women compared to non-traditional occupations with fewer than 5% women. In contrast to the early attrition, however, by year 3 of service, female sailors have lower odds of attrition from occupations with more than 25% women compared to women in non-traditional occupations with fewer than 5% women. In fact, female enlistees in MOSs with more than 25% women continue to retain at significantly higher rates out to year 5 than women in non-traditional occupations. Finally, Hartmann (2017) finds that among Navy officers, both men and women in occupations with more than 25% women have lower odds of retention until year 5 compared to occupations with less than 5% women. In other words, critical mass of women seems to matter more for retention of enlisted sailors than for naval officers.

Related Literature: Studies since Integration

The experience of the other services in integrating females into communities from which they were previously excluded could help to inform Marine Corps policy. Unfortunately, there appears to be a dearth of studies from all the services regarding experiences and performance of females since the combat exclusion was rescinded. The primary reason for this is that it is simply too early to tell. The numbers of females entering these occupational fields are small and they need time to complete their training and become proficient in their specialties. For example, as of March 2018, only 92 women (that is, 23 officers and 69 enlisted Marines) had joined a combat arms occupation (Snow, 2018). The numbers for the Army are larger—783 as of October 2018—but it is still too early for reliable statistical analyses (Myers 2018)—especially studies that would assess individual proficiency and resilience, as well as unit-level measures like readiness or combat effectiveness. See Swick and Moore (2018) for a more detailed report on progress as of April 2018. Kamarck (2016) provides a summary of the progress the services made approximately 12 months after the exclusion was lifted on behalf of Congress.

The studies that have appeared in the literature primarily address two broad categories. The first is prevalence and frequency of injuries in training and in the operating forces, especially as compared to similarly situated males. The second focuses on the development of physical training and fitness standards, particularly for those communities from which women were previously excluded.

The journal *Military Medicine* recently conducted a symposium on women in combat and published a number of studies on the topic in a special issue in a supplement to the January 2016 issue. While most of the studies avoid quantitative empirical analysis, several studies address issues that would be of interest to the Marine Corps, to include the role of peers and leadership on integration with respect to unit cohesion and individual performance (Segal et al., 2016), as well as various considerations of health outcomes for women and how they may differ from men (McGraw, Koehlmoos, & Ritchie, 2016). Of the empirical studies included in the symposium, Dye et al. (2016) compare injuries suffered in OIF and OEF, while Bradley et al. (2016) study physical fitness standards to meet the challenges of combat occupational fields.

A number of studies that focus on, or were sponsored by, the Army since 2015 have appeared in the literature, and tend to focus on performance standards and differential rates of injuries. In Foulis et al. (2017), the researchers develop a physical test battery to predict performance in combat military occupational specialties. They find that a test battery that consists of the medicine ball put, squat lift, beep test, and standing long jump is "highly predictive of performance of the Combat Arms military occupational specialties" (Foulis et al., 2017). This test appears to be similar in intent to the Marine Corps' Ground Combat Arms Initial Strength Test and MOS Specific Physical Standards Test. See Sharp et al. (2017) for a similar study on the Army Physical Demands Study, as well as Sharp et al. (2018) for information on the Occupational Physical Assessment Test, which are both efforts to quantify a standard of performance in order to facilitate female integration. Nindle et al. (2017) explore the effectiveness of functional training on female MOS performance. A few studies have emerged that examine the differences in injury rates between men and women in initial training and the operating forces. Among these are Dada et al. (2017), Hauret et al. (2017), and Rappole et al. (2018), which find that females suffer from various lower body and musculoskeletal injuries at higher rates than males.

The U.S. Navy removed the female exclusion from the submarine community in 2010. Integration of the first women officers into submarine crews followed shortly thereafter. Ellis and Munson (2015) provide an ethnographic analysis and outline the experiences of the first women officers assigned to submarines. In an interesting version of the "leaders first" concept to integration, they find that a senior female Supply Corps officer assigned to the same boat as the junior officers can add significant value to the integration process (Ellis & Munson, 2015, p. 97). These officers can both serve as mentors to the junior officers, while providing advice to the command element on the progress of the integration. The Enlisted Women in Submarines task force stood up in 2013. See Parcel and Parvin (2014) for a decision-support model for managing the female enlisted manpower for this community.

While the Marine Corps is the only service that maintains fully segregated initial training, the Air Force initial training is at least partially segregated by gender. A recent RAND study examines ways the Air Force might more fully integrate basic training by gender (Schaefer, Jones, et al., 2018). The courses of action they consider range from integrating select training activities to fully integrating the entire recruit experience.

Summary

This project contributes to several different streams of literature. First, it contributes to the broad thread of analysis of women in the military. It also contributes to the research on gender distribution within occupations. We employ a hedonic technique to estimate an equilibrium distribution of female Marines among Marine Corps Occupational Fields. Finally, we employ a number of manpower modeling techniques to estimate various managerial relevant aspects of this issue, such as the expected number of female graduates of infantry training, as well as estimating levels of Marines available for deployment.

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III. OCCUPATION-BASED FRAMEWORK FOR ASSESSING GENDER COMPOSITION

In order to develop estimates of feasible upper bounds of female representation across the USMC occupational fields, we first develop a crosswalk relating USMC military occupational specialties (MOSs) to their civilian equivalents in the Standard Occupational Classification (SOC) system. The thesis by Major Angela Zunic (2018) describes these efforts more thoroughly. In this chapter, we summarize these efforts and extend the analysis.

Developing an Occupation Crosswalk

The Bureau of Labor Statistics (BLS) develops the SOC used by federal agencies to classify workers into occupational categories for statistical analysis (BLS, 2018a). To develop the crosswalk we turn to two data sources: a website called My Next Move for Veterans (MNMV) developed by the U.S. Department of Labor to aid military service members transitioning into the civilian labor market, and the Occupational Information Network (O*NET). Occupational data in the O*NET are the result of comprehensive studies of how jobs throughout the U.S. economy are performed, including the required knowledge, skills, and abilities required for job performance.

To capture female representation at the occupation level, we turn to two additional data sources: (1) Census employment data from 2000 to 2017 in the Integrated Public Use Microdata Series (IPUMS; Ruggles et al., 2017), and (2) data over the same period on U.S. Marine Corps personnel maintained in the Total Force Data Warehouse (TFDW). Female representation extracted from the TFDW is based on the end of the calendar year statistics while the censuses are conducted annually.

We begin mapping MOSs to their civilian SOC equivalents by turning to the U.S. Marine Corps MOS Manual. Over the past 17 years, several USMC occupational fields and MOSs have undergone several reclassifications, while some were merged or deleted. We referenced the MOS Manual and various directives to develop a consistent mapping of MOSs over time.[1] To capture the primary population of interest, we also focus on Primary MOSs (PMOS).

Using data of detailed job descriptors from MNMV, O*NET, the MOS Manual, and prior literature, we develop a crosswalk of Marine occupational fields (PMOS) to its civilian equivalents (SOC). A majority of the PMOSs already have a related civilian occupation in the MOS manual. MOSs without an identified related civilian occupation includes Intelligence, Infantry, Communications, Field Artillery, chemical biological radiation nuclear (CBRN), and Aviation Command and Control.

For the MOSs without a related civilian occupation in the MOS Manual, we first try to match a U.S. Army occupation from the RAND study by Wenger et al. (2017). Wenger et al. (2017) attempts to better translate a soldier's occupational experience for a more successful transition/crosswalk to the civilian work force than what is already provided in existing crosswalks. This study surveyed soldiers to identify the best civilian job for them by comparing and matching occupations with the most similar skills required on the job. For instance, Wenger et al. (2017) find that infantrymen and firefighters in the civilian sector appear to be a good match because of the overlap in their work attributes, knowledge, skills, and abilities, including soft skills such as teamwork, communications, stress tolerance, and physical requirements of the jobs.

The Wenger et al. (2017) study provides a robust crosswalk for 10 Army MOSs, five of which we match with U.S. Marine Corps MOSs based on detailed occupational descriptors. For the remaining unmatched Marine Corps MOSs, we create an SOC crosswalk based on detailed job descriptors, including knowledge, skills, and abilities required for job performance as written in the USMC MOS Manual, MNMV, and O*NET. Zunic (2018) provides more systematic details on the matching algorithm.

[1] The references we used include (but are not limited to) the following: NAVMC 1200.1C, NAVMC 1200.1B, NAVMC 1200.1A Ch1, MCO 1200.17E, MarAdmin 484/17, MarAdmin 490/17, MarAdmin 495/17, MarAdmin 305/12, MarAdmin 430/17, and MarAdmin 497/14. To better represent gender changes over time, obsolete MOSs are also included in the tables and analyses.

Gender Distribution in USMC MOS vs. Civilian Equivalents

Table 3 reports the gender distribution across Marine MOSs and their civilian equivalents, for both officers and enlisted Marines. Of note, females are still only 4.5% of the firefighter population. Meanwhile firefighters are the identified civilian equivalent for Marine infantry group 1 (0311 Rifleman, 0331 Machine Gunner, 0341 Mortarman, 0351 Infantry Assault Marine, 0352 Antitank Missile Gunner) that currently has approximately less than 1% female representation.

At the Occupational Field (OccFld) level, the occupations with the least female representation are 03 Infantry (0.1% female), 08 Artillery (0.7%), and 18 Tank (0.8%). While these Marine jobs have only recently opened to women, these jobs' civilian equivalents also have very low female representation; Infantry and Tank map to Firefighters (4.5% female), while Artillery maps to Pilots of water vessels (6.2%).

Meanwhile, there are Marine occupations with more than just a handful of women. Across MOSs female representation is highest in 45 Communication (32.6% female), 31 Distribution (26.1%), and in 01 Manpower (24.6%). These occupations are equivalent to civilian SOCs that also attract women. For instance, Manpower maps to HR in the civilian sector, where women are 80.2%, and Comm maps to PR/photographers, where women are 64.9%. Distribution maps to Logisticians in the civilian sector, where women are 33.7%.

What Table 3 tells us is that while women make up 7–8% of the overall Marine Corps active component, the concentration of women varies widely across Marine occupational specialties. On the other hand, Table 3 also suggests that the proportion of women in civilian occupations that are most closely equivalent to the majority of Marine jobs remains low.

Table 3. MOS to SOC Crosswalk with Gender Representation Levels. Source: Zunic (2018).

			United States Marine Corps TFDW											U.S. Census Data IPUMS							
			2017		2015		2010		2005		2000			2015		2010		2005		2000	
MOS		# in MOS	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male	MOS Manual SOC	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male
01XX Manpower & Administration																					
grp1	O	457	32.2%	67.8%	31.0%	69.0%	33.1%	66.9%	31.2%	68.8%	29.3%	70.7%	11-3131	59.1%	40.9%	48.5%	51.5%	58.2%	41.8%	55.1%	44.9%
grp2	E	6,074	23.4%	76.6%	21.6%	78.4%	22.8%	77.2%	15.9%	84.1%	13.2%	86.8%	43-4161	80.2%	19.8%	80.7%	19.3%	84.6%	15.4%	75.1%	24.9%
02XX Intelligence																					
grp1	O	754	10.1%	89.9%	8.4%	91.6%	5.6%	94.4%	6.6%	93.4%	5.5%	94.5%	11-1021	30.8%	69.2%	29.2%	70.8%	27.6%	72.4%	26.3%	73.7%
0203	O	216	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	33-1021	3.8%	96.2%	4.1%	95.9%	5.2%	94.8%	2.8%	97.2%
grp2	O	134	13.4%	86.6%	10.2%	89.8%	10.1%	89.9%	7.9%	92.1%	9.2%	90.8%	33-1012	14.8%	85.2%	15.1%	84.9%	14.6%	85.4%	12.2%	87.8%
0211	E	529	4.0%	96.0%	2.6%	97.4%	0.7%	99.3%	0.0%	100.0%	0.0%	100.0%	17-1021	21.4%	78.6%	19.2%	80.8%	18.2%	81.8%	18.5%	81.5%
0231	E	2,072	14.8%	85.2%	13.3%	86.7%	14.6%	85.4%	11.6%	88.4%	7.9%	92.1%	33-3021	25.5%	74.5%	24.0%	76.0%	27.6%	72.4%	20.8%	79.2%
grp3	E	618	11.5%	88.5%	11.0%	89.0%	10.1%	89.9%	8.1%	91.9%	7.3%	92.7%	17-3031	9.9%	90.1%	9.5%	90.5%	9.9%	90.1%	8.4%	91.6%
03XX Infantry																					
0302	O	1,981	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	33-1021	3.8%	96.2%	4.1%	95.9%	5.2%	94.8%	2.8%	97.2%
0370	O	178	0.0%	100.0%	0.0%	100.0%	N/A	N/A	N/A	N/A	N/A	N/A	47-1011	2.8%	97.2%	2.9%	97.1%	3.0%	97.0%	2.7%	97.3%
grp1	E	21,097	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	33-2011	4.5%	95.5%	4.0%	96.0%	4.2%	95.8%	3.5%	96.5%
grp2	E	1,499	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	53-5020	6.2%	93.8%	3.8%	96.2%	2.8%	97.2%	3.9%	96.1%
04XX Logistics																					
0402	O	1,499	15.3%	84.7%	15.2%	84.8%	11.9%	88.1%	11.5%	88.5%	10.8%	89.2%	13-1081	33.7%	66.3%	33.6%	66.4%	34.6%	65.4%	32.8%	67.2%
0411	E	943	17.5%	82.5%	17.2%	82.8%	16.5%	83.5%	16.0%	84.0%	17.4%	82.6%	11-3051	20.1%	79.9%	18.0%	82.0%	16.1%	83.9%	16.2%	83.8%
grp1	E	2,156	13.1%	86.9%	12.2%	87.8%	9.6%	90.4%	8.6%	91.4%	8.9%	91.1%	43-5011	29.8%	70.2%	31.4%	68.6%	35.2%	64.8%	24.6%	75.4%
0451	E	241	8.3%	91.7%	7.5%	92.5%	5.8%	94.2%	7.5%	92.5%	4.8%	95.2%	53-2010	6.1%	93.9%	4.8%	95.2%	5.8%	94.2%	4.1%	95.9%
0471	E		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39-4031	27.1%	72.9%	18.5%	81.5%	30.7%	69.3%	28.4%	71.6%
05XX MAGTF Plans																					
0511	E	300	12.3%	87.7%	11.6%	88.4%	9.6%	90.4%	7.6%	92.4%	14.2%	85.8%	43-5061	58.8%	41.2%	57.2%	42.8%	56.1%	43.9%	53.1%	46.9%
0532	E	1	0.0%	100.0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13-1199	56.7%	43.3%	57.1%	42.9%	63.3%	36.7%	56.2%	43.8%
06XX Communications																					
0602	O	1,027	9.5%	90.5%	8.6%	91.4%	7.4%	92.6%	7.6%	92.4%	7.5%	92.5%	11-1021	30.8%	69.2%	29.2%	70.8%	27.6%	72.4%	26.3%	73.7%
grp1	E	5,056	8.8%	91.2%	10.0%	90.0%	10.1%	89.9%	8.7%	91.3%	4.0%	96.0%	2740XX	10.0%	90.0%	11.9%	88.1%	12.0%	88.0%	14.2%	85.8%
grp2	E	4,344	8.1%	91.9%	8.1%	91.9%	7.3%	92.7%	8.8%	91.2%	5.9%	94.1%	49-209X	6.8%	93.2%	4.5%	95.5%	3.8%	96.2%	6.6%	93.4%
08XX Field Artillery																					
0802	O	833	0.6%	99.4%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	47-1011	2.8%	97.2%	2.9%	97.1%	3.0%	97.0%	2.7%	97.3%
0811	E	1,852	0.1%	99.9%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	53-5020	6.2%	93.8%	3.8%	96.2%	2.8%	97.2%	3.9%	96.1%
grp1	E	822	0.8%	99.2%	0.1%	99.9%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	43-9011	44.8%	55.2%	48.8%	51.2%	49.0%	51.0%	51.6%	48.4%
11XX Utilities																					
grp1	E	1,410	9.1%	90.9%	8.2%	91.8%	10.7%	89.3%	14.0%	86.0%	13.0%	87.0%	47-2111	2.1%	97.9%	2.2%	97.8%	2.3%	97.7%	2.6%	97.4%
1161	E	391	2.6%	97.4%	2.9%	97.1%	1.6%	98.4%	1.8%	98.2%	0.8%	99.2%	49-9021	1.1%	98.9%	1.2%	98.8%	1.5%	98.5%	1.9%	98.1%
1171	E	683	10.2%	89.8%	11.0%	89.0%	7.8%	92.2%	10.7%	89.3%	7.4%	92.6%	51-8031	5.0%	95.0%	4.9%	95.1%	5.4%	94.6%	5.6%	94.4%
13XX Engineer, Construction, Facilities, and Equipment																					
1302	O	577	10.4%	89.6%	10.0%	90.0%	8.3%	91.7%	9.1%	90.9%	6.2%	93.8%	11-9021	7.4%	92.6%	7.2%	92.8%	7.4%	92.6%	6.7%	93.3%
1316	E	256	5.9%	94.1%	6.0%	94.0%	2.2%	97.8%	3.3%	96.7%	2.8%	97.2%	51-4120	5.1%	94.9%	5.4%	94.6%	6.4%	93.6%	7.1%	92.9%
1341	E	1,248	5.4%	94.6%	6.1%	93.9%	3.3%	96.7%	2.7%	97.3%	3.1%	96.9%	49-3031	1.2%	98.8%	1.2%	98.8%	1.6%	98.4%	1.2%	98.8%
1345	E	1,569	5.7%	94.3%	4.2%	95.8%	0.9%	99.1%	0.7%	99.3%	1.6%	98.4%	47-1011	2.8%	97.2%	2.9%	97.1%	3.0%	97.0%	2.7%	97.3%
1361	E	119	9.2%	90.8%	6.3%	93.8%	2.7%	97.3%	2.5%	97.5%	15.8%	84.2%	17-1010	27.4%	72.6%	27.2%	72.8%	23.6%	76.4%	21.1%	78.9%
1371	E	3,009	4.2%	95.8%	5.7%	94.3%	2.5%	97.5%	1.9%	98.1%	1.2%	98.8%	47-5031	9.3%	90.7%	9.3%	90.7%	9.2%	90.8%	7.0%	93.0%
1391	E	1,416	6.9%	93.1%	7.5%	92.5%	5.3%	94.7%	5.2%	94.8%	8.2%	91.8%	53-7070	5.3%	94.7%	2.9%	97.1%	4.5%	95.5%	3.5%	96.5%
18XX Tank, Assault Amphibious Vehicle and Amphibious Combat Vehicle																					
grp1	O	311	0.3%	99.7%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	33-1021	3.8%	96.2%	4.1%	95.9%	5.2%	94.8%	2.8%	97.2%
grp2	E	1,742	0.2%	99.8%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	33-2011	4.5%	95.5%	4.0%	96.0%	4.2%	95.8%	3.5%	96.5%
21XX Ground Ordnance Maintenance																					
grp1	E	1,559	4.6%	95.4%	3.9%	96.1%	3.2%	96.8%	2.6%	97.4%	3.9%	96.1%	49-9098	6.7%	93.3%	6.7%	93.3%	6.9%	93.1%	11.7%	88.3%
grp2	E	1,199	0.3%	99.7%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.1%	99.9%	49-3031	1.2%	98.8%	1.2%	98.8%	1.6%	98.4%	1.2%	98.8%
2161	E	149	2.7%	97.3%	1.2%	98.8%	1.8%	98.2%	1.3%	98.7%	0.7%	99.3%	51-4041	4.5%	95.5%	4.3%	95.7%	5.5%	94.5%	5.4%	94.6%
2171	E	455	1.1%	98.9%	1.2%	98.8%	1.4%	98.6%	3.7%	96.3%	3.2%	96.8%	49-9060	11.2%	88.8%	10.5%	89.5%	10.0%	90.0%	11.8%	88.2%
23XX Ammunition & Explosive Ordnance Disposal																					
2311	E	1403	18.5%	81.5%	15.9%	84.1%	13.2%	86.8%	13.4%	86.6%	11.4%	88.6%	47-5031	9.3%	90.7%	9.3%	90.7%	9.2%	90.8%	7.0%	93.0%
26XX Signals Intelligence/Ground Electronic Warfare																					
grp1	E	1,648	10.6%	89.4%	9.4%	90.6%	9.2%	90.8%	8.6%	91.4%	9.1%	90.9%	43-9011	44.8%	55.2%	48.8%	51.2%	49.0%	51.0%	51.6%	48.4%
grp2	E	571	15.3%	84.7%	12.6%	87.4%	16.0%	84.0%	14.0%	86.0%	14.5%	85.5%	2740XX	10.0%	90.0%	11.9%	88.1%	12.0%	88.0%	14.2%	85.8%
28XX Ground Electronics Maintenance																					
grp1	E	2,603	5.2%	94.8%	4.5%	95.5%	2.5%	97.5%	2.5%	97.5%	3.1%	96.9%	49-2020	9.7%	90.3%	12.4%	87.6%	11.7%	88.3%	12.9%	87.1%
30XX Supply Chain Material Management																					
3002	O	616	14.1%	85.9%	12.5%	87.5%	10.4%	89.6%	11.4%	88.6%	9.2%	90.8%	11-3061	47.2%	52.8%	45.0%	55.0%	11.7%	88.3%	40.2%	59.8%
3043	E	3,259	21.4%	78.6%	20.6%	79.4%	19.4%	80.6%	14.5%	85.5%	13.8%	86.2%	43-5081	34.4%	65.6%	36.7%	63.3%	36.5%	63.5%	35.7%	64.3%
3051	E	2,106	25.9%	74.1%	27.1%	72.9%	19.5%	80.5%	17.4%	82.6%	10.2%	89.8%	43-5011	29.8%	70.2%	31.4%	68.6%	35.2%	64.8%	24.6%	75.4%
3052	E	198	23.2%	76.8%	20.3%	79.7%	22.0%	78.0%	24.8%	75.2%	14.9%	85.1%	51-9111	53.9%	46.1%	57.1%	42.9%	56.6%	43.4%	58.4%	41.6%

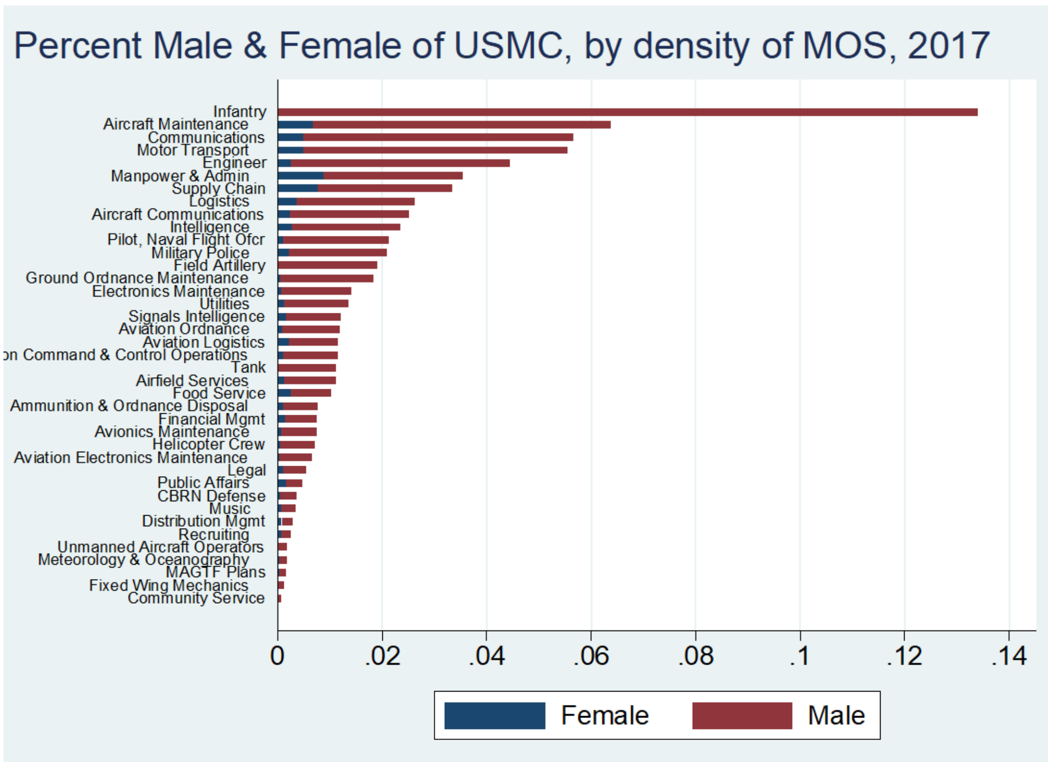
United States Marine Corps TFDW													U.S. Census Data IPUMS								
		2017			2015		2010		2005		2000			2015		2010		2005		2000	
MOS		# in MOS	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male	MOS Manual SOC	% Female	% Male	% Female	% Male	% Female	% Male	% Female	% Male
31XX Distribution Management																					
3112	E	510	26.3%	73.7%	25.1%	74.9%	18.4%	81.6%	17.1%	82.9%	14.9%	85.1%	13-1081	33.7%	66.3%	33.6%	66.4%	34.6%	65.4%	32.8%	67.2%
33XX Food Service																					
3381	E	1,881	23.9%	76.1%	20.1%	79.9%	14.1%	85.9%	13.2%	86.8%	12.7%	87.3%	35-2010	39.1%	60.9%	41.0%	59.0%	43.0%	57.0%	44.2%	55.8%
34XX Financial Management																					
3404	O	279	14.3%	85.7%	10.7%	89.3%	9.3%	90.7%	11.3%	88.7%	15.4%	84.6%	11-3031	53.6%	46.4%	54.4%	45.6%	52.3%	47.7%	53.3%	46.7%
3432	E	766	21.8%	78.2%	17.5%	82.5%	18.1%	81.9%	13.1%	86.9%	15.5%	84.5%	43-3051	88.1%	11.9%	90.2%	9.8%	89.4%	10.6%	89.1%	10.9%
3451	E	334	9.6%	90.4%	11.0%	89.0%	13.6%	86.4%	16.3%	83.7%	14.5%	85.5%	43-3031	86.9%	13.1%	88.8%	11.2%	89.0%	11.0%	89.9%	10.1%
35XX Motor Transport																					
3521	E	3,276	5.3%	94.7%	4.1%	95.9%	2.6%	97.4%	3.2%	96.8%	4.3%	95.7%	49-3023	1.5%	98.5%	1.4%	98.6%	2.0%	98.0%	2.0%	98.0%
3531	E	6,968	10.6%	89.4%	8.9%	91.1%	4.5%	95.5%	5.6%	94.4%	6.7%	93.3%	53-3030	5.8%	94.2%	5.3%	94.7%	5.4%	94.6%	6.0%	94.0%
44XX Legal Support																					
4402	O	536	13.1%	86.9%	13.5%	86.5%	12.5%	87.5%	10.7%	89.3%	7.1%	92.9%	23-10XX	40.1%	59.9%	36.7%	63.3%	35.1%	64.9%	30.7%	69.3%
4421	E	459	23.1%	76.9%	21.3%	78.7%	23.2%	76.8%	16.2%	83.8%	16.7%	83.3%	23-2011	83.5%	16.5%	85.9%	14.1%	85.1%	14.9%	86.2%	13.8%
45XX Communication Strategy & Operations																					
4502	O	145	33.1%	66.9%	29.1%	70.9%	23.1%	76.9%	25.0%	75.0%	21.4%	78.6%	11-2031	64.9%	35.1%	61.4%	38.6%	61.4%	38.6%	55.6%	44.4%
4512	E	131	32.1%	67.9%	24.1%	75.9%	18.0%	82.0%	15.5%	84.5%	10.8%	89.2%	51-5113	41.9%	58.1%	49.4%	50.6%	19.8%	80.2%	17.2%	82.8%
4531	E	276	34.4%	65.6%	28.1%	71.9%	25.0%	75.0%	19.9%	80.1%	22.1%	77.9%	27-3031	64.9%	35.1%	65.2%	34.8%	65.0%	35.0%	62.8%	37.2%
grp1	E	321	37.5%	62.5%	29.3%	70.7%	19.0%	81.0%	19.8%	80.2%	11.3%	88.7%	27-4021	48.4%	51.6%	45.9%	54.1%	42.2%	57.8%	38.7%	61.3%
55XX Music																					
grp1	E	642	13.1%	86.9%	12.8%	87.2%	14.1%	85.9%	16.1%	83.9%	N/A	N/A	27-2040	28.8%	71.2%	30.8%	69.2%	30.6%	69.4%	31.7%	68.3%
57XX Chemical, Biological, Radiological & Nuclear (CBRN) Defense																					
5711	E	678	9.1%	90.9%	6.4%	93.6%	6.3%	93.7%	4.9%	95.1%	5.7%	94.3%	19-4031	33.1%	66.9%	36.5%	63.5%	36.1%	63.9%	33.6%	66.4%
58XX Military Police, Investigations, & Corrections																					
5803	O	274	10.2%	89.8%	8.3%	91.7%	5.3%	94.7%	7.7%	92.3%	3.6%	96.4%	33-1012	28.7%	71.3%	27.1%	72.9%	26.5%	73.5%	25.0%	75.0%
5811	E	2,985	10.1%	89.9%	8.3%	91.7%	6.1%	93.9%	7.4%	92.6%	6.2%	93.8%	33-3021	25.5%	74.5%	24.0%	76.0%	27.6%	72.4%	20.8%	79.2%
5831	E	601	9.2%	90.8%	11.0%	89.0%	9.3%	90.7%	10.3%	89.7%	11.0%	89.0%	33-3010	27.3%	72.7%	28.2%	71.8%	27.5%	72.5%	26.2%	73.8%
59XX Aviation Command and Control (C2) Electronics Maintenance																					
5939	E	184	4.3%	95.7%	4.0%	96.0%	4.6%	95.4%	1.4%	98.6%	7.7%	92.3%	27-40XX	10.0%	90.0%	11.9%	88.1%	12.0%	88.0%	14.2%	85.8%
grp1	E	955	4.5%	95.5%	4.5%	95.5%	5.1%	94.9%	5.4%	94.6%	5.0%	95.0%	49-209X	6.8%	93.2%	4.5%	95.5%	3.8%	96.2%	6.6%	93.4%
5951	E	57	7.0%	93.0%	3.9%	96.1%	N/A	N/A	N/A	N/A	N/A	N/A	49-9060	11.2%	88.8%	10.5%	89.5%	10.0%	90.0%	11.8%	88.2%
60/61/62XX Aircraft Maintenance / Organizational Avionics Maintenance																					
6002	O	306	13.7%	86.3%	11.6%	88.4%	8.1%	91.9%	7.1%	92.9%	8.1%	91.9%	49-1011	7.3%	92.7%	7.4%	92.6%	8.1%	91.9%	14.2%	85.8%
6042	E	317	21.1%	78.9%	22.4%	77.6%	16.8%	83.2%	8.9%	91.1%	18.9%	81.1%	51-4120	5.1%	94.9%	5.4%	94.6%	6.4%	93.6%	7.1%	92.9%
6046	E	1,112	23.2%	76.8%	22.7%	77.3%	19.4%	80.6%	14.7%	85.3%	16.9%	83.1%	43-5061	58.8%	41.2%	57.2%	42.8%	56.1%	43.9%	53.1%	46.9%
6048	E	1,044	5.7%	94.3%	4.5%	95.5%	4.2%	95.8%	3.4%	96.6%	8.3%	91.7%	49-9098	6.7%	93.3%	6.7%	93.3%	6.9%	93.1%	11.7%	88.3%
grp1	E	7860	4.6%	95.4%	3.6%	96.4%	3.3%	96.7%	2.3%	97.7%	1.8%	98.2%	49-3011	5.5%	94.5%	4.9%	95.1%	5.2%	94.8%	5.2%	94.8%
6073	E	955	4.6%	95.4%	5.5%	94.5%	2.4%	97.6%	2.5%	97.5%	3.1%	96.9%	49-3040	1.3%	98.7%	1.3%	98.7%	1.3%	98.7%	0.8%	99.2%
6074	E	170	5.9%	94.1%	8.1%	91.9%	5.0%	95.0%	3.1%	96.9%	N/A	N/A	51-9010	11.0%	89.0%	13.7%	86.3%	10.6%	89.4%	14.3%	85.7%
grp2	E	1,312	5.5%	94.5%	3.6%	96.4%	2.6%	97.4%	1.5%	98.5%	2.7%	97.3%	53-2010	6.1%	93.9%	4.8%	95.2%	5.8%	94.2%	4.1%	95.9%
6258	E	212	7.1%	92.9%	3.6%	96.4%	0.0%	100.0%	N/A	N/A	N/A	N/A	49-2011	25.1%	74.9%	32.8%	67.2%	25.1%	74.9%	32.9%	67.1%
63/64XX Organizational Avionics Maintenance																					
grp1	E	4,619	9.1%	90.9%	7.7%	92.3%	7.4%	92.6%	6.2%	93.8%	5.4%	94.6%	49-2091	11.1%	88.9%	8.2%	91.8%	5.6%	94.4%	9.7%	90.3%
6469	E	681	8.1%	91.9%	5.5%	94.5%	6.8%	93.2%	5.8%	94.2%	3.1%	96.9%	49-1011	7.3%	92.7%	7.4%	92.6%	8.1%	91.9%	7.9%	92.1%
6492	E	390	3.8%	96.2%	3.4%	96.6%	5.5%	94.5%	6.3%	93.7%	3.4%	96.6%	49-9060	11.2%	88.8%	10.5%	89.5%	10.0%	90.0%	11.8%	88.2%
6499	E	286	9.4%	90.6%	6.9%	93.1%	N/A	N/A	N/A	N/A	N/A	N/A	49-9021	1.1%	98.9%	1.2%	98.8%	1.5%	98.5%	1.9%	98.1%
65XX Aviation Ordnance																					
grp1	E	2,184	6.9%	93.1%	6.5%	93.5%	5.7%	94.3%	7.1%	92.9%	7.9%	92.1%	49-9071	3.7%	96.3%	3.5%	96.5%	4.3%	95.7%	6.1%	93.9%
66XX Aviation Logistics																					
6602	O	242	15.3%	84.7%	11.9%	88.1%	7.3%	92.7%	13.8%	86.2%	10.5%	89.5%	11-3071	18.4%	81.6%	17.9%	82.1%	16.4%	83.6%	16.7%	83.3%
6672	E	1,514	21.1%	78.9%	22.7%	77.3%	20.3%	79.7%	18.6%	81.4%	19.1%	80.9%	43-5081	34.4%	65.6%	36.7%	63.3%	36.5%	63.5%	35.7%	64.3%
6694	E	383	7.0%	93.0%	5.8%	94.2%	6.9%	93.1%	6.8%	93.2%	N/A	N/A	11-3021	28.6%	71.4%	30.3%	69.7%	29.4%	70.6%	29.9%	70.1%
68XX Meteorology & Oceanography (METOC)																					
6842	E	315	16.2%	83.8%	13.3%	86.7%	7.5%	92.5%	4.9%	95.1%	5.6%	94.4%	19-2021	21.4%	78.6%	23.7%	76.3%	16.1%	83.9%	11.9%	88.1%
70XX Airfield Services																					
grp1	E	1,124	16.2%	83.8%	15.2%	84.8%	14.4%	85.6%	11.8%	88.2%	9.1%	90.9%	55-2020	21.1%	78.9%	18.8%	81.2%	16.3%	83.7%	20.5%	79.5%
7051	E	919	2.5%	97.5%	2.8%	97.2%	2.0%	98.0%	4.5%	95.5%	5.4%	94.6%	33-2011	4.5%	95.5%	4.0%	96.0%	4.2%	95.8%	3.5%	96.5%
72XX Aviation Command & Control Operations																					
grp1	O	365	15.1%	84.9%	13.3%	86.7%	12.7%	87.3%	16.4%	83.6%	11.3%	88.7%	53-2020	21.1%	78.9%	18.8%	81.2%	16.3%	83.7%	20.5%	79.5%
7204	O	53	1.9%	98.1%	1.8%	98.2%	0.0%	100.0%	0.0%	100.0%	N/A	N/A	53-2020	21.1%	78.9%	18.8%	81.2%	16.3%	83.7%	20.5%	79.5%
7212	E	342	4.1%	95.9%	1.0%	99.0%	0.0%	100.0%	0.0%	100.0%	0.0%	100.0%	49-1011	7.3%	92.7%	7.4%	92.6%	8.1%	91.9%	7.9%	92.1%
grp2	E	1,352	9.3%	90.7%	8.1%	91.9%	6.0%	94.0%	6.8%	93.2%	6.9%	93.1%	53-2020	21.1%	78.9%	18.8%	81.2%	16.3%	83.7%	20.5%	79.5%
73XX Navigators & Unmanned Aircraft System Officers/Operators																					
7315	O	115	4.3%	95.7%	1.1%	98.9%	N/A	N/A	N/A	N/A	N/A	N/A	53-2010	6.1%	93.9%	4.8%	95.2%	5.8%	94.2%	4.1%	95.9%
7314	E	194	5.7%	94.3%	4.7%	95.3%	4.9%	95.1%	3.9%	96.1%	5.1%	94.9%	17-2070	9.4%	90.6%	9.3%	90.7%	7.3%	92.7%	8.9%	91.1%
7372	E	10	0.0%	100.0%	0.0%	100.0%	7.1%	92.9%	3.6%	96.4%	2.6%	97.4%	53-2010	6.1%	93.9%	4.8%	95.2%	5.8%	94.2%	4.1%	95.9%
75XX Pilots/Naval Flight Officers																					
grp1	O	3,918	3.8%	96.2%	3.4%	96.6%	2.7%	97.3%	2.4%	97.6%	1.2%	98.8%	53-2010	6.1%	93.9%	4.8%	95.2%	5.8%	94.2%	4.1%	95.9%

total: 137,732

Average: 21.9%
Officer: 23.1%
Enlsited: 21.5%

Figure 2 shows the percentage of women in each OccFld as a proportion of the entire USMC, sorted by the size of that occupation. Infantry Marines comprise just under 14% of the USMC in this 2017 sample, but they represent the largest OCCFLD and where women are less than 1% of the occupation. And while women are about 25% of the Manpower MOS, Manpower & Admin itself is just a little over 3% of the entire USMC.

Figure 2. Percent Male & Female of USMC, by Density of MOS



Taken with the results in Table 3, in part because the Marine Corps organization (T/O) is disproportionately weighted toward civilian occupation equivalents with low female representation, it will likely be very difficult for USMC to increase its overall gender representation.

Hedonic Approach

Suppose we assume that the civilian labor market is sufficiently close to equilibrium, where men and women have sorted into occupations that best utilize their skills and abilities for which they get the best possible reward. Under this hedonic assumption and using the occupational crosswalk, we can then develop an econometric model where we regress representation on multiple job characteristics such as skills, abilities, and knowledge required for job performance using data from the O*NET. The coefficients on these regressors have the interpretation as the marginal proportion of women for a one-unit change in that job characteristic. Knowing what the detailed job descriptors of Marine OCCFLDS are, we can then predict the proportion of women for each OCCFLD.

More formally, we estimate the following equation:

$$Y_i = \beta_0 + \beta_1 Cognitive_i + \beta_2 Physical_i + \beta_3 Social_i + \beta_4 Language_i + \varepsilon_i \qquad (1)$$

where Y_i denotes the percentage of women in occupation *i*, and *Cognitive*, *Physical*, *Social*, and *Language* indicate the bundle of knowledge, skills, and abilities required for job performance. Because there is a multitude of occupational characteristics in the O*NET, and these variables are highly collinear, we employ big data techniques (specifically, principal component analysis) to compute job skill measures as composites of such data. The methodology and underlying O*NET variables to construct the *Cognitive*, *Physical*, *Social*, and *Language* skills indices are described further in Bacolod and Rangel (2017) and referred to in Zunic (2018).

The coefficients of these skill indices (β's) indicate the marginal proportion of female representation per unit change in the skill index. As detailed in Bacolod and Rangel (2017), the *Cognitive* skills index relates to a worker's developed capacities that facilitate learning or more rapid acquisition of knowledge for job performance. A high value on this index indicates higher requirements of problem-solving and critical and analytical thinking for job performance. The *Physical* skills index captures the physical demands for job performance, including degree of strength requirements as measured by the job's involvement in standing, walking, sitting, and lifting and carrying objects. The

Social index captures the socioemotional skills (e.g., people skills for teamwork) for job performance, while *Language* indicates the vocabulary and linguistic skills for job performance.

Estimates of Gender Composition in Marine MOS

Table 4 reports estimates of the regression equation specified in Equation (1) pooling all the data together. Table 22 in Zunic (2018) reports estimates by year.

Each skill index is normed with a mean of 1 and standard deviation of 0.1. Thus, the estimates in Table 4 show that an MOS in the USMC that requires a one standard deviation increase in cognitive skill requirements is associated with a 4 percentage point decline in female representation, all else held constant. Similarly, in civilian labor markets, the same unit increase in cognitive skills is associated with a 13 percentage point decline in females in those jobs.

In general, the direction of gender sorting across occupational skills is similar in the Marine Corps as in the civilian sector. While on average, occupations in the civilian sector have more women (the Constant), there are fewer of them in more jobs that require a lot of cognitive and physical skills. Women are more concentrated in jobs requiring language and communication skills. There is a similar pattern in the Marine Corps, where a one standard deviation increase in physical skill requirements is associated with 2.64 percentage point decline in female representation.

Table 4. Female Occupational Representation and Skills

VARIABLES	(1) IPUMS	(2) USMC
Cognitive Index	-1.296***	-0.403***
	[0.134]	[0.043]
Language Index	1.222***	0.176**
	[0.223]	[0.072]
Physical Index	-0.882***	-0.264***
	[0.105]	[0.034]
Social Index	-0.417**	0.017
	[0.174]	[0.057]
2005	0.002	0.002
	[0.025]	[0.009]
2010	0.014	0.007
	[0.025]	[0.009]
2015	0.012	0.021**
	[0.025]	[0.009]
2017		0.032***
		[0.009]
Constant	1.582***	0.552***
	[0.234]	[0.076]
Observations	353	445
R-squared	0.431	0.309

Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

To forecast the expected proportion of women in Marine occupations, we evaluate the coefficient estimates at the specific values of each USMC MOS's skills. For example, Table 5, reproduced from Zunic (2018), shows MOSs with cognitive skills that are the top 10 and bottom five among all USMC MOSs.

Table 5. Top and Bottom Cognitive Intensive USMC Occupations. Source: Zunic (2018).

PMOS	Female	soccode	Cognitive Index	Language Index	Physical Index	Social Index
Top 10						
7315	4.3%	532011	1.1812	1.0302	0.9450	1.0452
75grp1	3.8%	532011	1.1812	1.0302	0.9450	1.0452
7372	0.0%	532011	1.1812	1.0302	0.9450	1.0452
0451	8.3%	532011	1.1812	1.0302	0.9450	1.0452
60grp2	5.5%	532011	1.1812	1.0302	0.9450	1.0452
72grp1	15.1%	532021	1.1537	1.0740	0.8828	1.0160
70grp1	16.2%	532021	1.1537	1.0740	0.8828	1.0160
3521	5.3%	493023	1.1311	0.9833	1.0921	0.9557
6842	16.2%	192021	1.1301	1.1056	0.8719	1.0418
6258	0.0708	492011	1.1094	1.0054	0.9918	0.9635
Bottom 5						
2161	2.7%	514041	0.8860	0.8989	1.0756	0.9071
3531	10.6%	533033	0.8714	0.9159	1.1264	0.9402
3052	23.2%	519111	0.8534	0.9133	1.1630	0.8980
6672	21.1%	435081	0.8518	0.9000	1.0286	0.8943
3043	21.4%	435081	0.8518	0.9000	1.0286	0.8943

PMOS 7315—Unmanned Aircraft System MAGTF Officer is the PMOS group requiring the highest level of cognitive skills for job performance, while 3043—Supply Chain and Materiel Management Specialist requires the least amount of cognitive skills. Note the 7315 occupation is almost two standard deviations above the mean in demand for cognitive skills. In comparison, the 7315 MOS's other indices (language [1.03], physical [.945], and social [1.04]) are all within the first standard deviation of the mean. Based on model estimates, the predicted percent female in PMOS 7315 is 4.3%.

Using coefficient estimates from the 2017 model, Table 6 reports predicted female proportions for each 2-digit PMOS. The overall percent female in USMC is forecast at 8.82% when adjusted for USMC occupation skill content, and 18.6% unadjusted, using the 2017 model estimates. Of course, varying the model specification (e.g., adding higher order terms of the skill indices and interactions) will yield slightly different numerical predictions. By and large, however, under this hedonic approach and modeling assumptions, the predicted female representation hovers around 10% in the Marine Corps. The mechanism for this result is because the Marine Corps organization is disproportionately weighted toward occupations whose skill content are both cognitive and physical skill intensive and less linguistic and social skills intensive, and whose equivalents in the civilian labor market have low female representation.

Table 6. Predicted Female Upper Bound Adjusted for Skills and Abilities Required to Perform the Occupation. Source: Zunic (2018).

PMOS Occ Field	2017 Population	2017 Female %	SOC	Predicted Upper Bound for Female %	Predicted Upper Bound Adjusted for Skills and Abilities Required to Perform the Job
03	30,000	0.1%	33-2011	4.5%	0.0%
08	4,991	0.7%	53-5020	6.2%	9.5%
18	229	0.8%	33-2011	4.5%	0.0%
21	4,118	2.5%	49-9098	6.7%	2.9%
75	5,156	4.3%	53-2010	6.1%	5.3%
59	4,451	4.6%	49-2094	6.8%	8.1%
73	366	4.6%	17-3024	9.4%	10.6%
28	4,439	4.7%	49-2094	9.7%	8.3%
62	4,118	4.8%	49-3011	5.5%	8.1%
61	5,934	4.9%	53-2010	6.1%	5.3%
13	9,160	5.5%	47-5031	9.3%	5.1%
65	2,833	6.4%	49-9031	3.7%	5.1%
11	3,044	8.4%	47-2111	2.1%	10.9%
06	15,244	8.5%	27-4012	10.0%	11.8%
35	13,029	8.6%	53-3030	5.8%	10.7%
64	2,781	9.0%	49-2091	11.1%	8.1%
57	885	9.2%	19-4031	33.1%	11.1%
63	4,511	9.2%	49-2091	11.1%	8.1%
72	2,691	9.6%	53-2020	21.1%	13.1%
70	2,304	10.1%	53-2020	21.1%	13.1%
58	4,451	10.3%	33-3021	25.5%	9.2%
60	5,540	10.6%	43-5061	58.8%	18.0%
02	4,950	11.5%	33-3021	25.5%	9.2%
05	321	12.5%	43-5011	29.8%	18.0%
23	2,432	12.5%	47-5031	9.3%	5.1%
26	3,167	12.8%	43-9011	44.8%	16.3%
04	5,859	13.9%	43-5011	29.8%	17.3%
68	395	15.2%	19-2021	21.4%	11.4%
55	889	16.5%	27-2040	28.8%	11.1%
66	2,352	18.2%	43-5081	34.4%	14.4%
34	1,507	18.4%	43-3051	88.1%	15.1%
44	1,110	18.6%	23-2011	83.5%	12.5%
30	6,760	22.8%	43-5081	34.4%	14.4%
33	2,128	23.9%	35-2010	39.1%	13.2%
01	7,777	24.6%	43-4161	80.2%	17.9%
31	568	26.1%	13-1081	33.7%	15.6%
45	1160	32.6%	27-3031	64.9%	18.6%
Total	171,650	Weighted Averages		18.6%	8.82%

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IV. DETERMINANTS OF SUCCESS AT INFANTRY TRAINING BATTALIONS

Dove and Richmond's (2017) thesis anticipates the challenges of integrating women into previously closed combat occupations in the Marine Corps. Graduation rates remain relatively low for females attending USMC's enlisted infantry training school, Infantry Training Battalion (ITB). Over FY14–FY15, during the Marine Corps Force Integration Plan (MCFIP) study, Line of Effort (LOE) 2 entry-level training research at ITB-E, 65.92% of female Marines failed the Program of Instruction (POI). Upon official implementation of female integration into Marine infantry, no females passed the physical prerequisites necessary to even begin training at ITB throughout all of FY16. In FY17, four met the prerequisites to begin training but only two successfully completed POI at ITB.

Given the low graduation rates, Dove and Richmond (2017) attempt to identify the factors of success at infantry training and the common reasons for failure. In addition, they consider how their analysis informs the Marine Corps as they seek to expand female participation in the infantry MOS. In their own words, they hope to "provide commanders with the information necessary to better recruit and contract Marines, male and female, to the infantry who are most likely to succeed" (Dove & Richmond, 2017, p. 3).

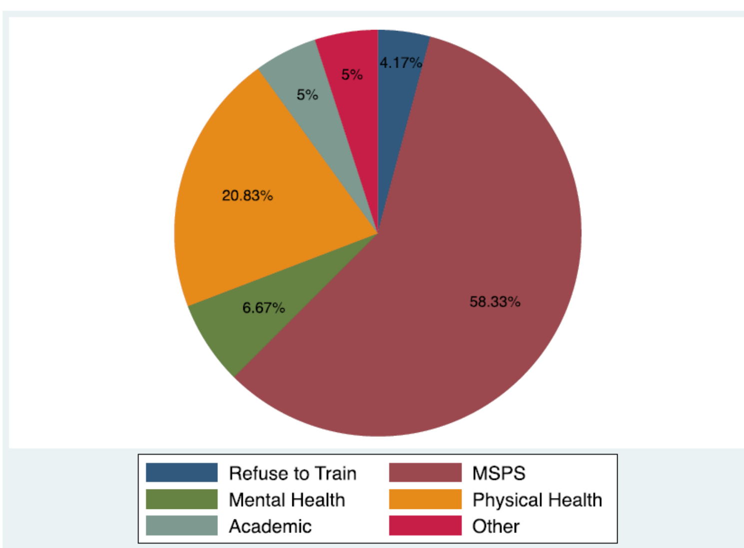
Dove and Richmond (2017) examine all male Marines who attended enlisted Infantry Training Battalion from 2010 to 2017, which amounts to 42,152 observations. The factors in their dataset include demographic factors such as age, marital status, height, weight, and ethnic group; performance factors such as Physical Fitness Test scores, Combat Fitness Test scores, and Rifle score; quality measures such as AFQT and ASVAB component scores; and effectiveness measures such as graduation success.

Dove and Richmond (2017) also leverage a dataset from ITB-West, which contains observations of male Marines who attended that school between October 2016 and February 2017. This accounts for eight classes for a total 1,676 Marines. This dataset contains slightly more detailed information, such as the component scores of the PFT and CFT, and most importantly, the reasons for failing, if applicable.

A multivariate logistic regression analysis of the large dataset in which the response variable is Graduation from ITB suggests that AFQT, PFT, CFT, Rifle Score, Height, and Weight all help to explain success at ITB. It is not surprising that measures correlated with cognitive ability or physical fitness are correlated with success at ITB. Regarding Height and Weight, it stands to reason that lean muscle mass is an important quality for infantry Marines. We find that holding height constant, additional weight is associated with greater likelihood of graduation. In other words, from this perspective greater lean muscle mass is positively correlated with success. In contrast, we find that when holding weight constant, increasing height is associated with lower likelihood of graduation.

Dove and Richmond (2017) also conduct multinomial logistic regression on the smaller, more detailed, ITB-West dataset. While there exist a wide variety of drop codes, i.e., reasons indicated for failure to graduate, the authors consolidate them into six categories. As Figure 3 illustrates, approximately 80% of all failures are associated with physical performance (MOS Specific Physical Standards: 59%) or physical health (21%). In addition, refusal to train is a substantial category.

Figure 3. Distribution of Reasons for Failure at ITB. Source: Dove & Richmond (2017).



The results from the multinomial regression are not as dramatic but indicate that Height and Weight are positively correlated with failure due to MSPS, while more time at the Movement to Contact (CFT event), more time at Movement Under Fire (CFT event), and fewer pull-ups (PFT event), that is, lower physical performance, is also positively correlated with MSPS-related failure. The model suggests that fewer crunches (lower physical performance) is associated with failure due to Physical Health reasons.

To summarize, this study highlights six statistically significant variables that correlate to success at ITB: AFQT, PFT, CFT, Rifle Score, Height, and Weight. In other words, physical ability and cognitive ability are major contributors to success. Dove and Richmond also find mental resiliency is a key factor. While their regressions do not have explicit measures of mental health, they show mental resiliency is an important factor as refusal to train is a major category for why ITB Marines fail.

Lee (2018) then follows the implications of Dove and Richmond's analysis by estimating the predicted probabilities of ITB graduation for the average male and female civilian. Lee turns to data from the California Department of Education (CDOE) of California high school students' measures of physical fitness equivalent to the constituent events in the Marines' PFT (i.e., pull-ups, crunches, mile run). These physical fitness outcomes are for the population of ninth graders in the state of California during the 2016–2017 school year. One limitation of this data is that ninth graders are typically 14–15 years old, when we'd ideally like to observe performance of 17-year olds. Using the CDOE dataset and estimates from the predictive model using the ITB data that Dove and Richmond (2017) developed, Lee (2018) finds that the expected probability that the average ninth grade male graduates from ITB is 0.89, while only 0.17 for the average female in the CDOE data. While on the face of it the gender gap in predicted graduation is not encouraging, analysis of CDOE data also shows that female youth capable of becoming Marines are higher in the quality distribution of their gender compared to male youth capable of becoming Marines. We discuss the implications of these gender differences in the context of a cost-benefit analysis in the next chapter.

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V. COST-BENEFIT ANALYSIS FRAMEWORK

This part of the study is not a formal cost benefit analysis due to the breadth of the scope and the limitations already stated; instead, it acts as a general framework for a cost benefit analysis by looking at two factors that affect force effectiveness: recruiting and readiness. We analyze the pool of individuals and the physical abilities of those individuals that the Marine Corps has to draw from for future accessions in order to compare the intensity of effort that must be expended to recruit females in comparison to males. Furthermore, this study examines the differences in deployability between males and females in order to see how readiness may be affected by changes in the current gender composition.

The CBA framework thus helps us to examine the implications of altering the gender composition on recruiting and readiness. In terms of implications for recruiting, the previous chapter on ITB shows there are substantial gender gaps in estimated probabilities of graduating from ITB. The estimated probability provides an avenue of approach to understand the intensity of effort that must be expended to alter the gender composition within the Marine Corps. We also consider the implications on readiness by analyzing the differences in deployability between males and females to determine the potential effects that a change in gender composition may have on the force's readiness.

Theory of the Firm as Applied to the Marine Corps: A Thought Experiment

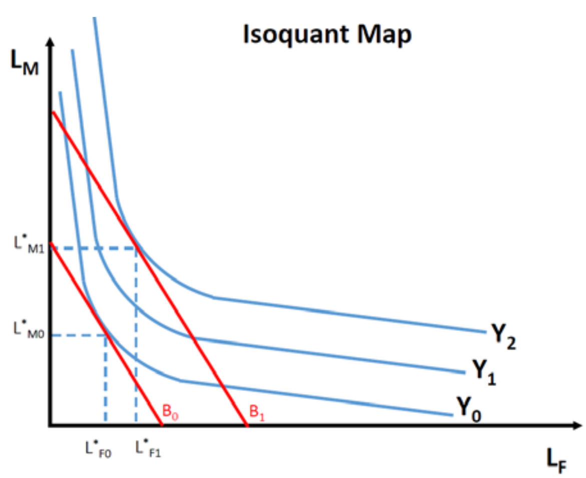
Though there are a number of critical differences between a for-profit business enterprise and the Marine Corps, it is worthwhile to imagine what insight the economics of the firm might provide the current problem. First, like any for-profit firm, the Marine Corps possess a production function. The production function for profit-seeking firms relates various combinations of factor inputs—such as capital, labor, and so forth—to output. Likewise, the production function for the Marine Corps would relate combinations of inputs (such as Marines, equipment, and weapons platforms) to output. The output of the Marine Corps is not a commodity, rather it is more along the lines of lethality or combat readiness.

Once we acknowledge the existence of a production function, we can imagine a number of ways to graphically depict some important relationships. First, since gender is the focus of this project, we differentiate between male labor (L_M) as an input and female labor (L_F). We can draw isoquants—that is, lines that depict all the combinations of male labor and female labor that result in a given output quantity (readiness or lethality level).

Next, we draw a budget constraint that embodies the amount contained in the total manpower budget. Thus, every point on the line is a different mix of men and women that may be employed at a given budget level. In addition, the slope of the line embodies the rate of substitution between males and females. If men and women cost exactly the same to hire, the slope of this line would be -1.0. However, we draw it a bit steeper to account for the fact that, in general, females tend to require more resources in terms of time and effort to recruit than men. We explore the latter phenomenon more fully below.

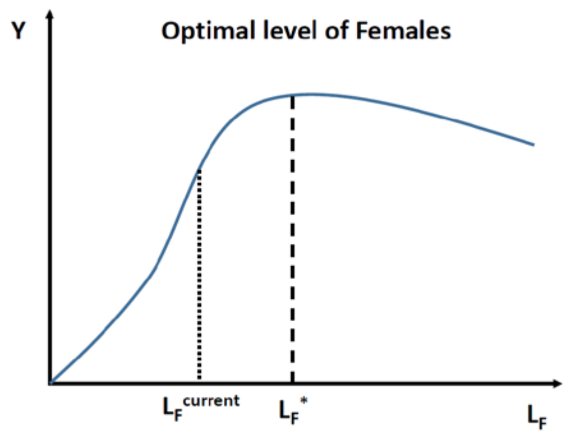
We then solve for the optimal mix of males and females by selecting the isoquant line that is just tangent to the budget constraint. Given a particular budget constraint B_0, we might imagine an optimal mix of male and female labor. Notice that given the shapes of the isoquants, even with a higher budget, B_1, the optimal mix would still include a relatively high proportion of men.

Figure 4. Isoquant Map of Trade-off between Male and Female Marines



Given the production function and the isoquant map, it is possible to identify an optimal level of females to employ. Figure 5 shows a notional relationship between the number of females as a factor input and the level of output. Given the fact that such a huge number of billets that had been closed to females prior to 2015 are now open to them, it is enirely plausible that the current level of females in the Marine Corps is lower than the optimal. Our previous analysis, particularly in section III, tends to suggest this as well.

Figure 5. The Optimal Level of Females in the Marine Corps



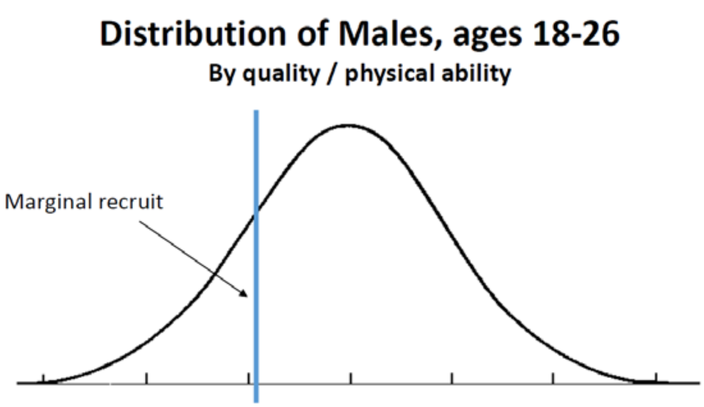
Unfortunately, it is impossible for us as researchers, or the Marine Corps as an institution, to identify this optimal level of female input with any degree of certainty or reliability. Due primarily to the fact that the Marine Corps lacks the ability to calculate profit and loss, it is simply incapable of discovering the level of females that maximize readiness or lethality. In short, we could never collect enough of the right information to draw the isoquant curves, let alone really ever quantify the effect of an additional Marine (of either gender) on lethality.

That said, the exercise described here was not without some value. For instance, if we were to actually craft a budget constraint, we would have to have a sense of the extent to which males and females differ in the costs of hiring them. We explore this notion in the following section. If we were to attempt to draw isoquant curves, we would have to have a sense of whether males and females contribute differently to the output of the Marine Corps. We also address these ideas further in the following section.

Gender Differences in Opportunity Costs: Continuing the Thought Experiment

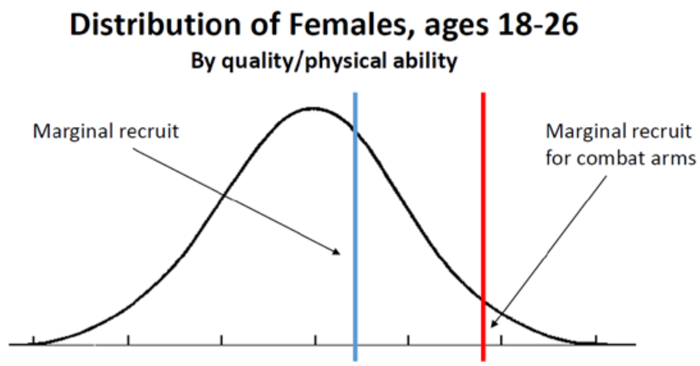
The prime ages of candidates targeted by recruiters are 18 to 26 years old. We can imagine taking all individuals in the population (who are not already associated with the military) and identifying those who are *eligible* for service in the Marine Corps (i.e. medically, mentally, and physically qualified). We can further imagine sorting those individuals by "quality" or their fitness for the Marine Corps. This quality value depends on athletic ability, cognitive abilities, etc. This notional distribution is depicted in Figure 6.

Figure 6. Distribution of Male Candidates by Quality



The marginal male Marine, that is, that individual who is just barely qualified to pass boot camp and go on to gain MOS proficiency, is likely approximately in the 30th percentile of this quality distribution. This idea is broadly consistent with the notion of the Cat-IIIB AFQT score. In addition, this marginal Marine—whomever he happens to be—would make just as good a rifleman as a (non-technical) non-combat arms Marine. Most important, the alternatives that this individual chooses between are relatively modest. We might surmise that if he didn't join the Marine Corps, he would probably work construction over the summer and consider enrolling in community college in the fall.

Figure 7. Distribution of Female Candidates by Quality



The corresponding quality distribution for females is shown in Figure 7. If we were to imagine the marginal female, that is, the individual who would just pass boot camp and go on to achieve MOS proficiency (in an MOS traditionally open to females), we might expect that individual to come from the neighborhood of the 55th percentile of the quality distribution, mostly due to the physical rigors of Marine life. The value of the alternatives this individual would give up to join the Marine Corps is likely significantly higher than that of the marginal male. This female could likely attend and successfully complete a four-year college program if she desired. Thus, the different values of the alternatives given up to join the Marine Corps help to explain the fact that it is generally more difficult in terms of resources and time to enlist a female than to enlist a male. Furthermore, if we were to imagine the marginal female who could just pass Infantry Training Battalion and go on to achieve MOS proficiency in the infantry (or other newly opened combat arms MOS), she is likely to come from significantly higher in the quality distribution. Due to the substantial physical requirements of infantry training, this female may come from as high as, say, the 80th or 90th percentile of the quality distribution. Her alternatives are even more valuable than the marginal female recruit. She may have the opportunity to attend a four-year college and play sports, perhaps even on an athletic scholarship.

The purpose of this guided thought experiment is to imagine reasons why the resources expended to recruit a female into the Marine Corps might be different than the resources to recruit a male. While we believe that anecdotal evidence more than confirms our conjectures concerning the value of alternatives each of these individuals might be confronted with, such a thought experiment is far from being scientifically sufficient. We examine JAMRs data in the following section in an effort to put this analysis on firmer empirical footing, in addition to the descriptive findings in Lee (2018) using CDOE data.

Deployability Gender Gaps: Empirical Evidence

In this section, we examine empirical data to begin to understand how males and females contribute to the Marine Corps' production function and determine along which margins those contributions might differ. Fleshing out this question would theoretically help researchers to draw the isoquant maps necessary to calculate the optimal factor mix.

Since we identify the output of the Marine Corps as lethality or combat readiness, it is clear that Marines deployed to combat zones and engaged in combat operations—or providing direct support to those combat operations—are directly contributing to the output of the Marine Corps. However, we must admit that since those deployments can be limited in both scope and frequency, it is more helpful to determine who is capable of deploying. In a very strong sense, since the Marine Corps is the nation's force in readiness, for an individual to simply be ready to deploy on relatively short notice is a necessary and sufficient contribution to the mission of the Marine Corps. So, at the most basic level, for an individual to be said to contribute directly to the mission of the Marine Corps, that individual must be *deployable.*

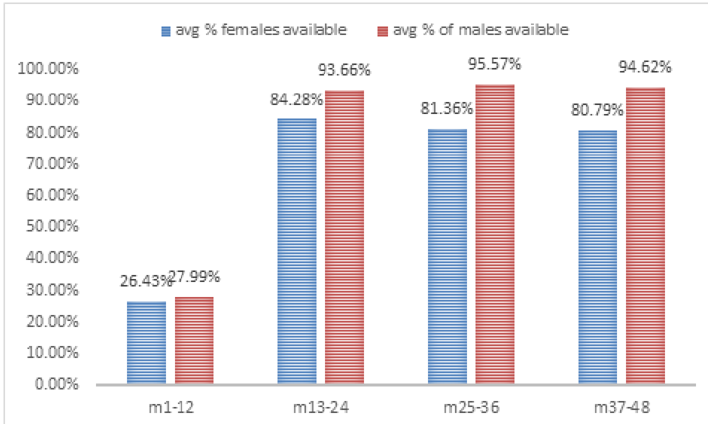
For a Marine to be officially available to deploy, they must satisfy at least three conditions. First, the individual must be on active duty. In other words, Marines who have left the Marine Corps are not available to deploy, by definition. Because we focus on the first term enlisted population, this can be a non-trivial number. Second, the Marine must fill an assignable billet, which means they must not be a patient, prisoner, trainee, or transient (P2T2). By far, Marines undergoing initial training comprise the largest component of non-assignable Marines. Third, they must be administratively "full duty." There are a variety of reasons why a Marine may not be full duty, but the most common tend to be medical conditions. For example, a Marine who is pregnant is placed in a limited duty status, as is a Marine who suffers a knee injury that would preclude them from performing all of their requirements. Other reasons for limited duty status might include legal hold or pending separation.[2] We declare a Marine who satisfies these conditions as available to deploy, or simply available.

Lee (2018) examines enlisted personnel records data from October 2009 to September 2017. For each Marine in the sample, she examines their first 48 months of service. Then she notes whether the individual was available to deploy for each of those months. We might expect, given a non-trivial proportion of females get pregnant during their first enlistment and that pregnancy results in a relatively long term of limited duty, females would tend to have lower rates of availability. However, we expect that males injure themselves and/or experience legal trouble at higher rates than females, so the sign on the difference is difficult to anticipate.

Figure 8 illustrates the difference in availability rates for males and females. In each of their first four years of service, males tend to spend a higher proportion of their time available for deployment. In fact, disregarding the first year where both genders tend to spend the vast majority of their time unavailable due to initial training, the difference between male and female availability tends to be approximately 10–14 percentage points. Note, this figure and subsequent figures in this section show the proportion of available, conditional on still being on active duty. Lee also examines an absolute measure of proportion of available that accounts for attrition rates as well (2018, p. 33). Because females tend to exhibit higher attrition rates, the resultant available rates are marginally lower than the ones shown here. (Thus, the difference between male and female rates is even greater.)

[2] Lee (2018) identifies non-deployable Marines through a Deployability Category variable provided by Manpower Information Division. It is based on such personnel data fields as Strength Category Code and Limited Duty Status Code.

Figure 8. Mean Proportion of Availability for Males and Females, Categorized by Year or Service



If we examine the monthly availability rates of females and males, for each of their first 48 months of service, we first notice that both genders spend a large proportion of their first year engaged in initial training (see Figures 9 and 10). We find that the top three categories associated with female non-availability over the course of the first four years of service are initial entry training, pregnancy, and medical conditions that limited full duty (see Figure 9). For males, the top three categories that caused unavailability over the course of the first four years of service were initial entry training, medical conditions that limited full duty, and PCS (see Figure 10). In each of the respective months, male available rates exceed those for females.

Figure 9. Female Proportion Unavailable, by Category

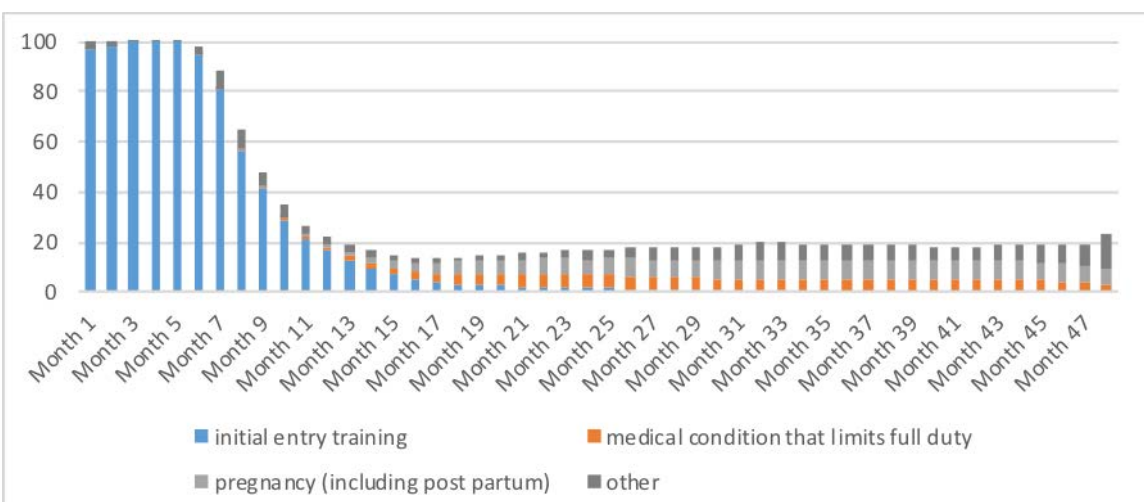
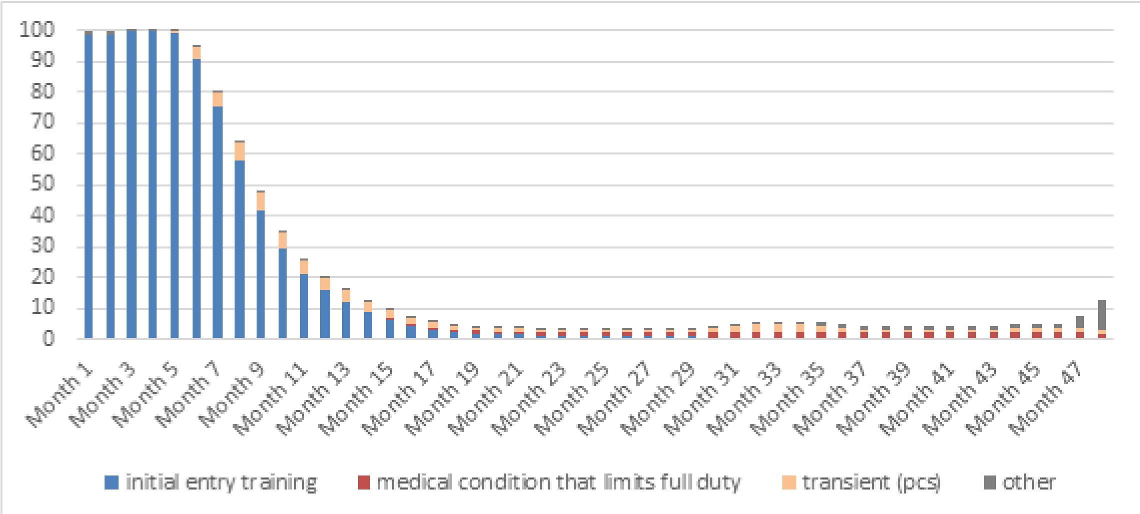


Figure 10. Male Proportion Unavailable, by Category



In addition, Lee examines each Occupation Field and attempts to relate female density to average available rates. There does not appear to be a statistically significant, or practically significant, correlation between the female density in an Occupation Field and the mean proportion of availability of the females in that field.

Alternative Opportunities: Limited Evidence from JAMRS

Our hypothesis is that the marginal female candidate who is just capable of attaining a combat arms MOS has a substantially higher opportunity cost to joining the Marine Corps than the marginal male. Namely, the marginal female combat arms Marine likely is college bound and, given the physical demands of combat arms MOSs, may very well have a scholarship to go to college to play a sport. In fact, the marginal female just capable of attaining an MOS that has traditionally been open to women also likely has a higher opportunity cost to joining the Marine Corps than the marginal male.

To explore the relationship between "quality" as it pertains to expected success in the Marine Corps and relevant alternative opportunities like college, we examine data collected as part of the Joint Advertising, Market Research & Studies (JAMRS) program.[3] JAMRS is a DoD program that seeks to gauge the opinions of young people with respect to military service in an efficient manner that avoids redundancy. For

[3] See https://jamrs.defense.gov/ for more information on JAMRS.

example, the JAMRS measures of the location of youths with propensity to serve is a primary input into Marine Corps recruiter requirements decisions. We analyze the Fall 2017 DoD Youth Poll in an effort to address our hypotheses.

The Fall 2017 DoD Youth Poll contains a sample of 5,683 (valid) respondents. The survey designers weight each observation in an effort to reflect the general population along a number of dimensions, to include gender, age, race, ethnicity, educational attainment, and region.

The survey consists of 71 questions. Questions 18–28 target respondents' propensity to join the military, with service-specific questions as well as component-specific questions. In addition, questions 29–34 ask respondents to self-report their knowledge of these career options, as well as their reasons for why they might consider joining the military. We generate our primary propensity-related response variable from Question 21, which asks (from p. 11 of the survey),

> In the next few years, how likely is it that you will be serving in any of the following Military Services? (Please make sure to provide a response for each of the Services.)
>
> 1=Definitely
> 2=Probably
> 3=Probably not
> 4=Definitely not
> -97=Multiple Response
> -99=Refused

We consider respondents who answer 1 or 2 to "Marine Corps" (variable: *FFP10D*) to be "propensed" for service in the Marine Corps.[4]

Our task is to use the survey data to determine the extent to which "high quality" members of the pool of youths eligible for recruitment into the Marine Corps might enjoy other alternatives from which to choose, like college. Unfortunately, the survey only asks respondents about their academic qualifications. It is almost certainly the case that cognitive ability is correlated with success in the Marine Corps and that cognitive ability is correlated with academic success in high school. However, given the physically

[4] The variable in the dataset that captures propensity to join the active duty component of *any* service is *COMP1*.

demanding nature of the job, especially for combat arms Marines, the fact that the survey does not ask anything about athletic ability or sports participation is a critical limitation of this section.

Nonetheless, there are five questions that are proxies for (self-reported) academic quality (pp. 6–7):

> Question 8: What grades do you or did you usually get in high school?
>
> Question 9: What is or was your high school grade point average?
>
> Question 10: Do you or did you take high school honor/AP/IB classes?
>
> Question 12: Have you taken the SAT or ACT?
>
> Question 13: Have you gone on a campus visit or college tour to help you learn more about attending a specific college or university?

Questions 8 and 9 look quite similar, but their responses have minor differences in levels. We use Question 9 in the analysis mainly because the answers in terms of GPA are more precise than those for Question 8 (i.e. mainly As, mainly Bs, etc). Furthermore, we consider a response of 1 (GPA of 3.75 or higher) as evidence that the respondent likely has valuable options for college. The other three questions (10, 12, and 13) are yes-or-no questions. We consider "yes" answers to these questions as suggestive of good opportunities for college.

Question 16 provides a useful variable that we use as a response variable and independent variable. The question states (p. 9):

> In the next few years, how likely is it that you will be attending each of the following types of schools or colleges?
>
> 1=Definitely
> 2=Probably
> 3=Probably not
> 4=Definitely not
> 5=Already completed
> -97=Multiple Response
> -99=Refused

The sub-parts ask for responses regarding respondents' plans from high school to graduate school. We consider answers of "Definitely" to "4-year college or university" as evidence of the respondents' desire to attend college.

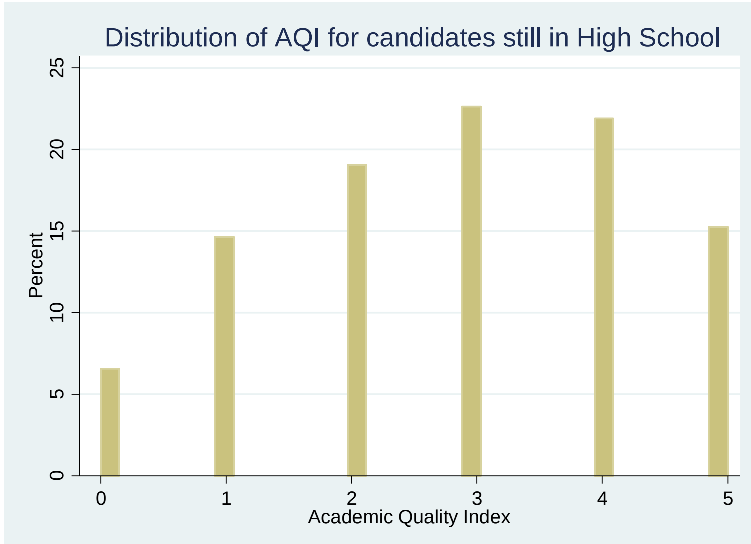
Approximately 70% of all high school graduates enroll in college in the following fall.[5] Thus these individual measures are not as helpful as we would prefer, because they cannot differentiate between the highest quality students who go off to college and those with fewer options. In an effort to mitigate this problem, we also create an index of academic quality (AQI), which we might use to tease out those students who seem most likely to have valuable options for college. In the index, the respondent gets one point for each of the following:

Question Number	Index Component	Full Sample Mean	In High School Mean
9	GPA of 3.75 or higher	0.32	0.34
10	Taken honors classes	0.63	0.65
12	Taken the SAT or ACT	0.80	0.75
13	College campus visit	0.68	0.57
16	Definitely college-bound	0.46	0.50

Figure 11 is a histogram of the distribution of AQI among those respondents still in high school.

[5] https://www.bls.gov/news.release/hsgec.nr0.htm

Figure 11. Distribution of AQI



Next, Figure 12 compares the propensity of males and females to join the Marine Corps, as a function of high school grade point average. While both males and females in the category with highest grades both have extremely low propensity (0.02), propensity for males increases dramatically for those with even slightly lower grade point averages. In contrast, mean female propensity for the Marine Corps is less than 0.05 for any grade point average greater than 3.0.

Figure 12. Male and Female Propensity to Enlist and GPA

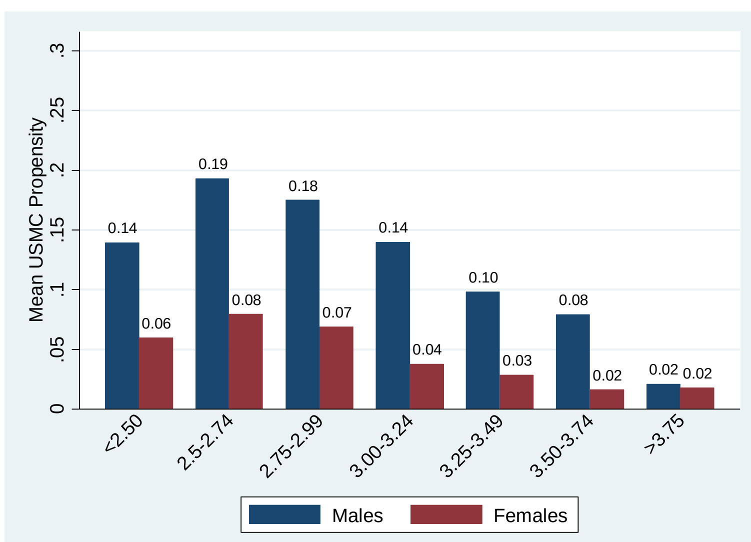
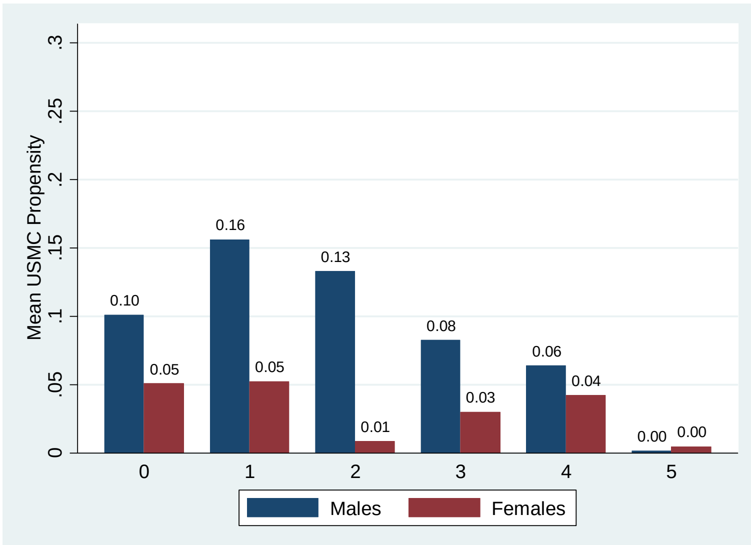


Figure 13 shows the same data, but as a function of AQI. The same relationship seems to hold. That is, the very highest quality males and females exhibit very low propensity, while propensity for males increases in most other groups. In contrast, the propensity of high quality females to enlist is generally lower than that of lower quality females—solely as measure by AQI.

Figure 13. Male and Female Propensity to Enlist and AQI



Ultimately, our analysis in this section is severely limited by the unavailability of physical fitness related data, or records of sports participation. However, the data are generally consistent with the narrative that the Marine Corps must compete with college for highly qualified candidates and even more so for highly academically qualified females.

There is one place in this research project where we consider athletic ability of high school attendees. Lee (2018) examines data from the California Department of Education statewide physical fitness tests and employs Dove and Richmond's regression model to predict how the average male may differ from the average female in their ability to successfully complete the USMC Infantry Training Battalion and earn an infantry

MOS (pp. 21–26, 31–32).[6] She finds that the average civilian male is 5.2 times more likely to be successful than the average female (Lee, 2018, p. 31).

Lee's findings are broadly consistent with our message that there are relatively fewer physically qualified females than males. However, there are a number of important limitations to her analysis. First, the physical fitness test data is all aggregate data and simply shows a count of those participants who are sufficiently athletic to be in the "Healthy Fitness Zone" (HFZ). Since we do not actually have access to the distribution of results for any particular test, Lee uses the minimum thresholds to achieve HFZ status. Second, the participants in the observed test data are in ninth grade. Their test scores are almost certainly going to change in the next three years, though it is not entirely clear in which direction the bias might point. Finally, the test data is only from California. While the fact that California is such a populous state affords us some protection, this analysis relies on California high school students being representative of the rest of the country.

[6] For more information about the physical fitness test data, see https://www.cde.ca.gov/ta/tg/pf/pftresearch.asp

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VI. CONCLUSIONS AND RECOMMENDATIONS

Women currently make up approximately 8% of the active component of the Marine Corps, a number well less than half of the proportion of women in the other military services. Currently, the Deputy Commandant for Manpower and Reserve Affairs has no tools at his disposal to assess whether 8% is too many or too few. This research provides multiple empirical analyses and develops a cost-benefit analysis framework, from which the Marine Corps may ultimately determine the optimal number of women in the Marine Corps.

Our first set of analyses estimates econometric feasible upper bounds in the proportion of women in Marine occupational fields. We begin by constructing a mapping of Marine occupations to its civilian equivalents by matching on each job's detailed descriptors, including knowledge, skills, abilities, and tasks required for job performance. Under the hedonic approach and assuming the civilian labor market is sufficiently close to equilibrium, we use the occupational crosswalk to estimate the expected proportion of women for each Marine OCCFLD.

We find a very heavily male-dominated civilian sector for equivalent Marine occupations. Specifically, the previously male-only Marine occupations in combat arms are largely equivalent to civilian occupations such as firefighting, where female representation currently still sits at or below 5%. This highlights the occupational segregation across civilian labor markets, indicating a low supply of female workers choosing to be in or being hired for such jobs. Meanwhile, infantry Marines comprise just under 14% of the USMC in 2017, but they represent the largest OCCFLD and where women are less than 1% of the occupation. While women are about 25% of the Manpower MOS, Manpower & Admin itself is just a little over 3% of the entire USMC. Given that the Marine Corps organization (T/O) is disproportionately weighted toward civilian occupation equivalents with low female representation, it will likely be very difficult for USMC to increase its overall gender representation.

Our research also offers a cost-benefit analysis framework for thinking about the implications of gender integration. The framework highlights that in order for the Marine

Corps to think about costs and benefits of accessing additional females, it must compare the intensity of effort and resources to expend to recruit females in comparison to males, taking into account the relative distributions of physical and cognitive abilities by gender, while balancing against their relative benefits. A full treatment of benefits would likely require a rigorous structural analysis to appropriately estimate the value of the work the additional women would provide the Marine Corps. For example, one possible method would be to use the value of the candidate's next best civilian alternative as a measure of the value of their work. Such an analysis is beyond the scope of this current effort, however.

What we instead examine empirically on the benefits side are the likely implications of integration on force readiness. We document significant gender gaps in deployability. Meanwhile, we also offer evidence consistent with the idea that young females capable of becoming Marines and attaining Marine physical standards are higher in the quality distribution of their gender relative to young males. What this means is the likely recruiting effort for female Marines may significantly vary from the recruiting effort for male Marines.

Thinking about the "optimal" number of women in the Marine Corps is fraught with multiple issues. Alternatively, the Marine Corps could spend some time deciding what to optimize. The cost-benefit analysis framework we offer, which maximizes an objective such as lethality/readiness, is one such alternative.

We recommend further research on constructing an MOS to SOC crosswalk. This can be done using survey instruments administered to Marines in those particular jobs, inquiring on the particular skills, abilities, work styles, work content, and others, for job performance. Such an enhanced crosswalk would be valuable for determining the next best opportunities for Marines in the civilian labor market, which in turn can answer multiple manpower planning policy questions.

We also recommend further research into ways to more clearly identify gender differences in recruiting effort intensity. Finally, since our analysis reveals injuries were a substantial reason for failure from ITB, we also recommend a more focused study on the determinants of injuries at ITB.

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